CREST : California Residential Energy Saving Tips

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CREST

California Residential Energy Saving Tips

A Thesis

Presented to

The Faculty of the Department of Environmental Studies

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree Master of Science

By

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December 2000

UMI Number: 1402509

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ABSTRACT

CREST: California Residential Energy Savings Tips
A Software Program

by Annette Grønlund

This thesis descibes the development of a software program that will allow California residents to identify the most energy efficient options for their homes, based on their climate. Climate was interpolated from existing climate stations in California. Energy efficiency recommendations were matched to those climates. The user of the program locates the general location of their home on a map of California on the computer. A list is produced showing the best appliances for that home, as well as insulation recommendations, and overhang dimensions that can be applied to the home's south side for optimal passive solar heating and cooling.

Acknowledgements

I would like to thanks David B. Kees for his gracious support and assistance.

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CHAPTER 1

INTRODUCTION

Motivation

There are numerous problems related to the residential use of electricity and natural gas in California. The most significant of these are the environmental problems associated with the harmful pollutants released into the atmosphere during the generation of electricity. Moreover, California's economic benefits derived from the electricity and gas trades are limited by its dependency on other countries and states as suppliers. In addition, many Californian's pay unnecessarily high utility bills every month due to energy inefficient homes, appliances and habits. Reducing energy consumption in homes can lessen these problems.

Electric generating plants that burn fossil fuels produce carbon dioxide, sulfur dioxide, and nitrous oxides (EPA 1995). Of electricity consumed in California, 51 percent is produced from fossil fuel burning plants*, primarily natural gas and coal (CEC 1997). Carbon dioxide from these plants adds to the build-up of green house gasses in the atmosphere contributing to global warming. Additionally, nitrogen oxides emitted from electricity and natural gas consumption are a major component of photochemical smog (IPCC 1990). Acid rain results from sulfur dioxide being released into the atmosphere, primarily from coal and oil burning power plants (IPCC 1990).

* 1997 electric mix for California including imports: Natural gas 30%, coal 21%, petroleum or diesel 0.07%, large hydro 23.1%, nuclear 15.1%, geothermal 4.9%, small hydro 2.2%, biomass 2.2%, wind 1.1%, solar 0.3% (CEC 1999).

California is heavily dependent on other nations and states to meet its energy needs. This results in the unnecessary outflow of capital from the local economy. Of the 243.9 billion-kilowatt hours of electricity consumed in California in 1997, 51.2 billion-kilowatt hours, or 21 percent, was imported. Of this, 10 percent came from Pacific Northwest hydroelectric powerplants and 11 percent came from Southwest coal-fired powerplants (California Energy Commission 1999).

Of the 1,922.87 billion cubic feet of natural gas that Californians consumed in 1993, 86 percent was imported. Of this, 20 percent came from Canada and 66 percent came from other regions within the United States. Within the United States, 54 percent came from the southwest and 12 percent came from the Rockies (California Energy Commission 1995). These figures are expected to increase in the future with more dependence on out-of-state and out-of-country contributions. By the year 2011 it is estimated that California will import 90 percent of the natural gas it consumes, with Canada's contribution increasing to 30 percent, the Rockies increasing to 18 percent, and the Southwest declining to 42 percent (California Energy Commission 1994).

Many energy efficient technologies are available that can reduce residential energy use. "The world's residential and commercial buildings face a promising future of energy-efficient operation, if there is sufficient will to put all the new technology to use" (Energy Innovations 1997). Residential energy efficiency is a cost effective means to reduce California's air pollution, reduce dependence on outside energy sources and lower utility bills for many households.

Background

This section discusses residential energy consumption in California, climate effects on energy use, California's historical energy use, energy efficiency standards, building standards, demand side management programs, and barriers that have slowed the acceptance of energy efficient technologies.

Residential energy consumption

Californians consumed 243.9 billion kilowatt-hours of electricity in 1997 (California Energy Commission 1999). Of those, 73.2 billion kilowatt-hours, or 30 percent, was consumed by residential customers. In 1994 California consumed 23.95 billion therms of natural gas. Of those, 5.28 billion therms, or 22 percent, was consumed by residential customers (California Energy Commission 1995).

The effects of climate on energy use

Climate plays an important role in the amount of energy used to heat and cool homes. Variations in average winter and summer temperatures have a nearly linear impact on energy use for heating and cooling (Schipper and McMahon 1995). Thus, California's diverse climate plays an important role in the amount of energy used in different locations throughout the state.

Climate in California varies greatly. For example, from northern coastal towns to southern dessert communities, average summer highs range from 62°F to 114°F, respectively. Winters are just as diverse. From mountain towns to southern coastal communities, average daytime highs range from 38°F to 70°F, and average nighttime lows from 8°F to 48°F (NCDC 1992). This diversity makes it difficult to provide uniformly useful information about home energy efficiency to California residents.

Residential Energy Efficiency

History

In response to federal and state policies and public perceptions following the energy crisis of the 1970's, energy demand per household declined 27 percent in California between 1970 and 1993 (Schipper and McMahon 1995), surpassing the national decline of 19 percent (Energy Innovations 1997). An example of this decline is the amount of heating used per household in California. In 1973, Californians used an average of 682.56 BTU's per year. This steadily declined until 1991, when the average use per dwelling was 426.6 BTU's (Schipper and McMahon 1995). While this was in part due to falling occupancy levels, "It appears that policies such as building code standards, appliance standards and utility demand side management programs helped to reduce residential energy use," (Schipper and McMahon 1995).

Energy efficiency standards

Federal appliance standards, such as those adopted in the 1987 National Appliance Energy Conservation Act (NAECA) and the 1992 Energy Policy Act (EPACT), have proven to be effective. In just five years, standards authorized by NAECA and EPACT have already saved roughly 2.5 quads* of energy (about 3 percent of total US annual energy use) corresponding to fifteen billion dollars in energy expenditures (Energy Innovations 1997). These policies established federal energy efficiency standards for refrigerators, freezers, central and room air-conditioners, water heaters, furnaces, dishwashers, clothes washers and dryers, direct heating equipment, kitchen ranges and ovens, pool heaters, fluorescent lamp ballasts, office equipment, electric motors, and other minor household appliances.

California implemented its own appliance energy standards beginning in 1977 when it initiated minimum efficiency standards of 71 percent for gas furnaces (Schipper and McMahon 1995). That standard took effect on December 22, 1983. Industry statistics from 1981 show that in California, 90 percent of furnaces sold had an AFUE ** rating of 66 to 70 percent. In 1984, all furnaces sold in California had AFUE ratings equal to or greater than 71 percent, while nationally, 76 percent of furnaces sold had ratings below 71 percent AFUE. Standards for refrigerators, air conditioners and room air conditioners were also set in 1979 (Schipper and McMahon 1995).

* One quad=10^{15} Btu

** This rating refers to the annual fuel utilization efficiency (AFUE) which is the measure of how effectively the furnace converts the heat content of the fuel into space heat (Wilson and Morrill 1997).

Building standards

California has been a leader among the states in energy related building codes. California's energy efficiency building code standards for new construction, known as Title 24, took effect in 1978. These building codes, based on sixteen climate zones within California, address the following (California Energy Commission 1995):

- Appliances regulated by the Appliance Efficiency Regulations
- Other space conditioning equipment
- Other service water heating equipment
- Pool and spa heating systems and equipment
- Gas appliances
- Doors, windows, and fenestration products
- Joints and other openings
- Insulation
- Lighting control devices

Title 24 exceeds the federal standards, known as the CABO Model Energy Code, required by the National Energy Policy Act of 1992 (Schipper and McMahon 1995). States must meet or exceed federal standards.

Demand side management

Utility Demand Side Management (DSM) programs have been very effective in encouraging consumers to purchase appliances that were more energy efficient than required by federal or state standards. In 1991, the residential DSM programs sponsored by Pacific Gas and Electric (PG&E) resulted in a savings of 47,132 MWh of electrical energy and 8.3 million therms of natural gas (PG&E 1992). One of these programs was a refrigerator rebate offer. During a four month period in 1991, PG&E provided rebates for refrigerators that were at least 20 percent more efficient than federal standards. As a result, 54 percent of refrigerator sales in the PG&E territory had efficiencies at or greater than 20 percent more efficient than federal standards. Sales of these efficient models in a control group outside of PG&E's territory were 5 percent or less. Estimated electricity savings from this program were 13 million kWh (Schipper and McMahon 1995).

Barriers to further energy conservation

Despite these successes, the adoption of cost-effective energy efficiency improvements remains far below the maximum potential because of the following barriers (Energy Innovations 1997):

- Imperfect information - Residential customers may not choose a new energy-efficient technology because they are unaware of the choices or their implications.

- Time consumption - While there are many choices, package labeling is inconsistent and information on energy use is often missing. Most consumers will not spend the time tracking this kind of information.

- Payback - Many consumers require that the energy-efficient measures have extremely short payback times before making an investment.

The first two barriers can be lessened by providing easy-to-use information, - the goal of this work.

CHAPTER 2

PROBLEM STATEMENT

This thesis describes the development of a software program that can be easily used to determine the most energy efficient appliances and upgrades for homes in any climatic region of California. This was accomplished by compiling information about energy efficient appliances and products and matching them to climate variables. This program will be referred to as California Residential Energy Saving Tips (CREST). In addition to providing information on energy efficient appliances and retrofitting that are appropriate to the local climate, CREST will provide general energy saving tips that are not climate dependent. CREST will allow California residents to understand their energy options and will help lower the information barrier that currently exists.

There could be several uses for CREST. Retail outlets could use it to assist customers in determining which appliances and retrofits are best for their home. Contractors could use CREST when building new homes to determine what energy efficient options are available and to determine overhang dimensions for passive solar design. Contractors can also use this program when retrofitting older homes to make energy efficient choices on upgrades. Utility companies could use CREST when giving advice to their customers on energy saving products that will work particularly well in the customer's area. CREST will be useful whenever a decision about the best choice of energy efficient applications must be made.

CHAPTER 3

ENERGY EFFICIENCEY AND CLIMATE EFFECTS

The following section includes an overview of related research in the field of residential energy efficiency. Topics include climate zones and residential energy savings, climate-sensitive software used to identify options to improve residential energy efficiency, energy efficient technologies and large appliance data.

Climate Zones and Residential Energy Savings

Current literature that deals with energy efficient retrofits and appliances tends to be general and does not take local climate into account. For example, the American Council for an Energy-Efficient Economy's book, Consumer Guide to Home Energy Savings, states that, "If there isn't any insulation, the best option is to bring in an insulation contractor to blow cellulose into the walls (Wilson and Morrill 1997)". There are many locations in California and elsewhere where this would not be a cost-effective retrofit. The cost to insulate existing walls in an eighteen hundred square foot home is approximately two thousand dollars (Kees 1999). Most homes in California are heated with natural gas. The average annual natural gas bill for California residents in 1992 was $265.13, which corresponds to approximately 442 therms a year (California Energy Commission 1995). A portion of this goes to the water heater and in some homes the range and clothes dryer. A forty-gallon gas water heater for a family of four consumes approximately 240-360 therms a year, with the most efficient forty-gallon unit on the market using about 214 therms a year (Wilson and Morrill 1997). In a household using this efficient water heater and whose only other gas appliance is the furnace, this leaves 228 therms per year for heating. Realistically a homeowner can expect to save 10 percent on their heating bill by insulating their walls (Penn 1992). 10 percent of 228 therms would be approximately twenty-three therms a year of savings or fourteen dollars. The payback of this investment would not be realized in a lifetime.

Many experts agree that climate varies so greatly that they are unable to make recommendations for individual homes. Amory Lovins, the renowned physicist, energy consultant and author states, "climates vary too much for us to recommend the best buys for your home." He recommends customers call an energy auditor (Lovins 1994). CREST can function as a low-cost virtual energy auditor for California if made publicly available.

Existing programs designed to link energy efficient appliances or retrofits with climate tend to have poor spatial resolution and are therefore not very accurate. For example, the publication California Climate Zone Descriptions for New Buildings, produced by the California Energy Commission, divides the state into sixteen climate zones based primarily on summer and winter mean temperatures. This manual is used to determine Title 24 building code standards for new buildings in California. In this publication, they state that, "within some climate zones, micro-climates are much more like another climate zone; but for considerations of ease of enforcement and simplicity, the Commission kept climate zone boundaries fairly consistent with jurisdictional boundaries and avoided creating pockets within zones" (California Energy Commission 1995). Due to the improved spatial resolution of CREST, which interpolated climate for

635 sections in California, the problem of the boundaries and pockets created by California Energy Commission's zones are minimized.

Another example that uses course spatial resolution is Lawrence Berkeley Laboratory's (LBL), Improving the Thermal Integrity of Single-Family Residential Buildings: Documentation for Regional Database of Capital Cost and Space Conditioning Load Savings (Koomey et al 1991). This report was used to determine the potential for additional cost and space conditioning load savings for new single-family buildings by improving efficiency beyond the current practices. This was the first report that attempted to model costs and energy savings for all regions in the United States. It used ten different regions, each of which contains from four to eight states. Within each region a city that best represents the average weather for that region was chosen. This selection was performed by a software program that puts Standard Metropolitan Statistical Areas (SMSA)* into climate groups based on climate characteristics and population size (Ritschard et al 1992). With this program, the larger the population, the more weight is given in considering its climate. From this information, a single city is chosen to represent each region for this analysis. Los Angles, CA was determined to be the "average city" for Federal region nine, which includes the states of Arizona, California, Hawaii and Nevada (Koomey et al 1991).

* SMSA's are areas defined by the US Office of Management and Budget as: (1) a county or group of contiguous counties that contain at least one city of 50,000 inhabitants or more, or (2) an urbanized area of at least 50,000 inhabitants and a total SMSA population of at least 100,000. The contiguous counties are included in an SMSA if, according to a certain criteria, they are essentially metropolitan in character and are socially and economically integrated with the central city (Department of Energy 1993).

To combine these four states into one region and base the climate on Los Angles because of its high population is perhaps understandable for a nationwide study; however, it will not produce accurate energy recommendations for large portions of region nine. As indicated earlier, the potential energy savings in California alone will vary widely due to its many varied climate zones.

Another example of a work that looks at climate in a broad sense while trying to make energy efficiency recommendations is Lawrence Berkeley Laboratory's web page, the Home Energy Saver (http://hes.lbl.gov/). This program gives users estimates of their homes' energy bills based on its location and provides recommendations on energy efficient upgrades. The user begins by entering their zip code. The zip code provides a "weather city" for their location. * There are problems with this approach. For example, several large population centers are not well represented by their weather cities. For example, when a San Jose or Gilroy zip code is entered, San Francisco appears as the weather city. San Francisco does not climatically represent either San Jose or Gilroy well. San Francisco's average highs and lows for August are 65°F/55°F, while San Jose's and Gilroy's are 82°F/56°F and 88°F /53°F, respectively. San Jose and Gilroy have summer heat problems, while San Francisco does not. Another example of a weather city that does not have warm summer highs but represents cities that do are in towns east and northeast of San Diego. These towns, such as Alpine and Campo, get

* For California, there are thirteen weather cities: Arcata, Bakersfield, Burns, OR, Daggett, Fresno, Long Beach, Los Angeles, Phoenix, AZ, Reno, NV, Sacramento, San Diego, San Francisco and Santa Maria.

very warm in the summer months, with temperatures in the 90° F's. LBL's web page shows their weather city as San Diego, which has an August average high temperature of 78° F.

In addition, recommendations on this web page omit important energy-saving appliances. One major appliance that is not mentioned or recommended on this web site is the evaporative cooler. There is not even a selection for an evaporative cooler when describing your existing cooling appliances. This thesis not only provides information on evaporative coolers and how energy efficient they are compared to an air conditioner, but it proves that the majority of California has a suitable climate for their use.

Energy Efficient Technologies

There are many energy efficient products on the market today and a lot of information available about these products. Many of these products only perform well under certain climate conditions. Some of the literature on these products does indicate the range of climate conditions in which they perform best, but does not indicate where these climate conditions are located. There is no comprehensive guide on the market today that allows California homeowners or builders to see which appliances or retrofits are best suited to their local climate.

Space conditioning and human comfort

In terms of primary energy, space conditioning represents over half of all energy consumption in residences (Department of Energy 1992). In 1989, California residences used approximately 6.8 billion kilowatt-hours for cooling. This is projected to increase to 8.13 billion kilowatt-hours by the year 2011 (California Energy Commission 1993). The number of homes with air-conditioners in the United States grew from 36.6 million (39 percent of all homes) in 1990 to 42.1 million (44 percent of all homes) in 1993 (Department of Energy 1993). Air conditioners are high energy-consumers. There are many energy-efficient alternatives that can be used effectively in much of California, such as evaporative coolers, whole house fans, fans, proper insulation and shading.

Air conditioners

The process used to cool air with an air conditioner is known as vapor-compression, or the refrigeration cycle. Air-conditioners include five main components (Abrams 1986):

Refrigerant - a fluid that transports heat through the system, using evaporation and condensation, alternately, to absorb and reject large amounts of heat.

Evaporator - the indoor heat exchanger where the refrigerant absorbs heat by evaporating from a liquid to a vapor.

Condenser - the outdoor heat exchanger where the refrigerant gives off heat when it is condensed from a vapor to a liquid.

Compressor - a pump that moves the refrigerant through the system and provides a pressure difference that allows the refrigerant to evaporate and condense.

Expansion device - a flow-control device that regulates the flow of the refrigerant and maintains the pressure differential in the system.

The size of air conditioning units is measured in tons. By definition, each ton can remove 12,000 BTU's of heat per hour from the home. Appropriate sizing of the unit depends not only on the size of the house, but on other factors such as climate and how well the house is weatherized. Generally, air conditioners have a ton of capacity for every four hundred to one thousand square feet of floor space (Krigger 1994). Air conditioners are also rated by their efficiency, using the Seasonal Energy Efficiency Rating (SEER), which is equal to how many Btu's per hour the unit removes divided by how many watts it uses to do so (SEER = Btu per hour/watts). Units built before 1979 had a SEER ranging from 4 1/2 to 8 (Krigger 1994), but today the national efficiency standard for central air conditioners requires a minimum SEER of 10 (Wilson and Morrill 1997). While these new units use less energy, there are other cooling appliance options that are even more efficient. Table 1 compares the energy usage of cooling appliances to that of an air conditioner with a SEER rating of 10.

Table 1.-Energy use comparison

Cooling Device	Watts
Central air-conditioner	2000-5000
Heat pump	2000-5000
Window air-conditioner	1500-2600
Central evaporative cooler	330-1000
Window evaporative cooler	125-500
Whole-house fan	300-600
Ceiling fan	25-75

Source: John T Krigger, Residential Energy: Cost Savings and Comfort for Existing Buildings, (Minnesota: Quality Books Inc., 1994), 186.

Although central air conditioners are the most effective at lowering air temperature, proper use of energy saving techniques throughout the home can reduce or eliminate the need for a central air conditioner. If an air conditioner can be replaced with one or more of the above applications, significant amounts of energy can be saved.

Evaporative coolers

The most energy efficient and cost effective option available, when cooling is necessary in dry regions, is the evaporative cooler. As table 1 shows, evaporative coolers are far more energy-efficient than central air-conditioners. Evaporative coolers cost about half as much to install as central air conditioners and use about 25 percent as much energy for equivalent cooling (Krigger 1994).

Evaporative coolers work by passing air over a wet pad that cools the air by evaporation. There are three different types of evaporative coolers on the market today, direct, indirect and dual-stage coolers. The direct evaporative cooler passes outside air through a wet, fibrous pad and then directly into the house. The indirect evaporative cooler cools the outside air in the same manner that the direct cooler does, but rather than passing the cooled moist air into the home, the air is vented past a heat exchanger. Air to be supplied to the home flows across the other side of the heat exchanger and is cooled without receiving moisture directly (Abrams 1986). The advantage of the indirect evaporative cooler is that the moisture from the evaporative process is not vented into the home and therefore the indoor humidity levels are not changed. Indirect evaporative coolers provide relatively low-cost cooling, but are approximately 30 percent more expensive to purchase than direct evaporative coolers.

These coolers are effective in areas that have outdoor highs of 85°F to 95°F and low humidity, preferably 50 percent or lower (Otterbein 1996). There are large regions in California where such coolers would provide adequate cooling. In these areas direct or indirect evaporative coolers would be the most economical system to purchase and operate.

In locations with higher temperatures and humidity, the dual-stage evaporative cooler can be cost effective. The dual-stage evaporative cooler uses an indirect evaporative cooler as the first stage and a direct evaporative cooler as the second stage (Santamouris & Asimakopolous 1996). Outside air is passed through a wet pad, which cools it, and then passed by a heat exchanger. The inside air is then vented past the heat exchanger, cooling it. This pre-cooled inside air is then run through a direct stage evaporative cooler. The advantage of this is that the air being cooled by the second stage is lower in temperature that the outside air but not higher in humidity. Lowering the dry-bulb temperature, but not raising the wet-bulb temperature of the air before passing it through the second stage produces much cooler air. These systems can effectively cool very hot air with modest relative humidity. These coolers use about a third of the energy of a comparable sized air-conditioning unit providing the same cooling capacity. Dual-stage evaporative coolers are the highest priced and best-performing evaporative coolers (Otterbein 1996).

Heat pumps

Heat pumps are mechanical devices used for heating and cooling. They operate by moving heat from a cooler to a warmer location. For example, in the winter, heat is removed from a cooler outside source (air, water, or earth) and delivered into the home. In the summer, heat is removed from the cooler indoor air and delivered outside (PG&E 1996). Heat pumps use a vapor-compression cycle that contains a refrigerant and has four basic working parts: a compressor, two heat exchangers (one serves as a condenser and one as an evaporator), and an expansion device. Heat pumps work in the same manner as an air conditioner or refrigerator.

Heat pumps are an economical heating choice in areas where natural gas is not available. Air to air heat pumps use outdoor air as a heat source. They have performance limitations based on the outdoor winter temperatures. Air to air heat pumps are efficient only in climates where winter temperatures do not fall below 32°F (DOE 1990). When temperatures fall below 32°F, back up electric resistance heat is used. This reduces the efficiency by approximately one third. In areas where winter lows do fall below 32°F, a geothermal heat pump could be used. Geothermal heat pumps use the earth as the heat source. While the expense of installation is greater, they are not limited by outdoor air temperatures since soil temperature below five feet remains an almost constant 55°F throughout the year (Department of Energy 1994). They are often installed under the home's foundation or driveway, or vertically.

Whole house fans

In many parts of California, ventilation can replace or reduce the need for air conditioning. The primary intent is to reduce interior building temperatures by promoting airflow through the building when the ambient air is cooler than that in the interior. Whether this replaces the need for mechanical cooling or just shortens the length of time the home needs mechanical cooling, it will save energy. Nighttime ventilation is very effective in this regard, particularly for the arid climates typical of California, where nights are cool (Parker 1992).

A good option for enhancing ventilation is a whole house fan. Whole house fans are installed into the ceiling of the home, between the living space and the attic. When turned on, the whole house fan draws the air from the house up through the attic and out the attic vents. Meanwhile, windows are opened in the house to create a breeze as outside air moves in to replace the air being drawn into the attic. This not only cools the air in the home and removes the built up heat in the thermal mass of the interior living space, but it also removes the hot air from the attic. The cost of installation and purchase of a whole house fan is approximately three hundred dollars (Kees 1999). They cost approximately three to five cents an hour to run, versus thirty-three to seventy-five cents for an air conditioner. By turning on the fan for half-an-hour in the evening to cool down the house, the need for air conditioning could be eliminated altogether in some areas. Whole house fans are only useful when the indoor temperature is greater than the outdoor temperature (Department of Energy 1989).

Fans

Fans are another energy efficient cooling option. While fans do not lower the temperature of the air, they increase air movement over the skin to help you feel cooler. Tests have shown that people feel just as comfortable in gently moving air (1.7 miles per hour) at 82°F as they do in calm air at 78°F (Krigger 1991). Thus, using fans allows the thermostat of the air conditioner or evaporative cooler to be set 4 °F higher, which translates into significant energy savings. Supplementing the air conditioner with ceiling fans can result in net energy savings for cooling of 15 to 35 percent (Department of

Energy 1989). Some climates in California are cool enough to have ceiling fans replace the need for mechanical cooling all together. Ceiling fans are also useful in the winter to mix warm air that settles near the ceiling with the cooler air below.

Insulation

To reduce the need for heating and cooling, the home must be properly insulated. Insulation slows the rate of heat transfer through the building shell, thereby reducing winter heat loss and summer heat gain. Insulation is measured by its resistance to heat flow, or its R-value (ASHRAE 1977):

$$q = UA\Delta T = \frac{A\Delta T}{R_{value}}$$

Where q = total conductive heat flow through the insulation ($Btus/hr$).

U = overall heat conduction coefficient ($Btus/ft^2 hr.^o F$).

A = area of material (ft^2).

ΔT = temperature difference across insulator ($^o F$).

The higher the R-value the more resistant the insulation is to heat flow. All new construction since 1973 is required by California state law to insulate to a certain level, which varies by location. However, many older homes in California have little or no insulation. According to Housing Characteristics 1993, produced by the Department of

Energy, many households have barely adequate or below adequate insulation in the western region of the United States. Only 39 percent of homes are well insulated, while 38 percent are adequately insulated, and 23 percent are poorly insulated.

Shading

In a typical house, solar gain through windows accounts for 15 to 20 percent of cooling costs. Solar gain through the roof and walls account for another 20 to 30 percent (Krigger 1992). With no shading of south and west windows and walls, the interior temperature of a typical house could rise as much as 20°F on a hot day (Wilson & Morrill 1997). Lawrence Berkeley Laboratory conducted a comparative study on the effects of shading pre-1973 houses, which had little to no attic insulation and no wall insulation, and homes built in 1980, which had adequate attic and wall insulation. This study showed that planting three trees around the pre-1973 homes, one on the west and two on the south side, could reduce space conditioning energy use during the summer in hot climates by 13-20 percent, corresponding to an annual savings of ninety to one-hundred seventy dollars. Planting three trees around the homes built in 1980 showed a decrease in energy used for cooling of 10-16 percent with an annual savings of sixty to one-hundred twenty dollars (Huang 1990). Clearly, there are certain areas in California that would benefit from reduced solar gain in the cooling months. Deciduous trees are recommended by CREST for shading in warm areas.

Overhangs are another effective method of keeping sun from heating the home during the summer months. Overhangs on south windows can reduce summer heat gains by as much as 65 percent (Santamouris and Asimakopoulos 1996). CREST will provide overhang dimensions for homes that can be utilized for roof overhangs, awnings, or trellis. These dimensions are calculated using the home's latitude.

Lighting

Lighting accounts for 5-10 percent of total energy use in the average American home (Wilson and Morrill 1997). For indoor home lighting, four types of bulbs are prevalent: incandescent bulbs, halogen bulbs, fluorescent bulbs and compact fluorescent bulb. Incandescent light is produced by a tiny coil of tungsten wire that glows white-hot when it is heated by an electrical current. Only about 10 percent of the electricity used by an incandescent bulb actually produces light; the rest is lost as heat (Wilson and Morrill 1997). Halogen bulbs, a type of incandescent bulb, are filled with a halogen gas and have a heat-reflective inner coating that keeps the tungsten filament hot with less electricity (Krigger 1994). This results in more light output per watt and a longer bulb life than a standard incandescent bulb (Department of Energy 1986). Halogen bulbs have a life of twenty-five to thirty-five hundred hours; about 2 ½ to 3 ½ times that of a standard incandescent bulb, and produce about one-tenth more light per watt.

Fluorescent bulbs produce approximately four times more light per watt than incandescent bulbs (Florida Solar Energy Group 1992). Fluorescent bulbs contain an inert gas at low pressure. When an arc is struck between the lamp's electrodes, electrons collide with atoms in the gas to produce ultraviolet radiation. This, in turn, excites the white phosphorus coating of the bulb that emits light at visible wavelengths (Schaeffer et al 1994).

Compact fluorescent bulbs, which were introduced in the early 1980s, work like standard fluorescent bulbs but have a screw-in base that fits into a conventional socket (Wilson and Morrill 1997). Compact fluorescent bulbs have an average life of 10,000 hours while an incandescent bulb has an average life of only 750 hours. Therefore, it takes approximately thirteen incandescent bulbs to provide the same 10,000 hours of light as one compact fluorescent bulb. A compact fluorescent bulb costs approximately $12.00 while an incandescent bulb costs around $0.75. Since it takes thirteen incandescent bulbs to match the life of one compact fluorescent bulb, the total cost for the incandescent bulbs would be $9.75, somewhat less than the compact fluorescent bulb price. A twenty-watt compact fluorescent bulb gives off as much light as a seventy-five-watt incandescent bulb. The cost in electricity (at $0.105 per kWh) to run one twenty-watt bulb for 10,000 hours is $21.00, whereas the electricity cost to run thirteen seventy-five-watt bulbs for 10,000 hours is $78.75. Table 2 illustrates the substantial savings obtained from using one twenty-watt compact fluorescent bulb instead of thirteen seventy-five-watt incandescent bulbs.

Table 2. -Incandescent versus fluorescent bulbs

	Standard Incandescent	Compact Fluorescent
Bulb cost for 10,000 hours:	13 @ $0.75=$9.75	1 @ $12.00
Electricity for 10,000 hours: (At $0.105 kWh)	$78.75	$21.00
Total Cost for 10,000 light hours	$88.50	$33.00
Total Savings	$88.50-33.00 = $55.50	

Large Appliances

Refrigerators

Increased Federal efficiency standards for refrigerators and freezers took effect in 1993. After 1993, the average refrigerator/freezer* had to consume less than 704 kWh annually (California Energy Commission 1993). In comparison, older units of the same size consumed 1,500 to 2,500 kWh per year (Meier 1993). Based on current residential electric rates in California, replacement of an older refrigerator with a new post 1993 model would result in a net energy savings of $84.00 to $189.00 a year.

Clothes Washers. More than 95 percent of clothes washers in the United States are top loading units that spin on a vertical axis. Vertical axis machines, based on the 1994 National Appliance Energy Conservation Act, must use less than 1.77 kWh/cycle. As of 1997, the most efficient model on the market used 1.62 kWh/cycle (Wilson and Morrill 1997). Horizontal washers, that are either front or top loading, use less energy to run and require less water. Horizontal axis machines use between 0.63 kWh/cycle and 0.69 kWh/cycle. This is equivalent to an electric savings of $0.10-$0.12 per load. Aside from electric savings, horizontal washers reduce water use by 50 percent due to the fact the washtub is only partially full. Because they use less water, they require less energy to heat the water and require less detergent. Hot water savings will vary from $0.02 per load for loads washed in hot and rinse in cold water with a gas water heater to $0.12 per load for loads washed in hot and rinsed in cold water with an electric hot water heater. There will be additional savings for residents where water is metered. The amount of detergent required is about two thirds of that required for a vertical axis machine (California Energy Commission 1993).

Horizontal washers cost an estimated $250 more than vertical models. The savings per year will varying depending on how many loads of laundry are done, the temperature of the water used, the cost of detergent and the commodity used to heat the water. Outside of electricity, water and detergent savings, these washers may create less wear and tear on clothes by eliminating the agitators and they are not prone to load

* a $19 ft^3$ automatic defrost unit with a top-mounted freezer and without through-the-door service.

imbalance problems characteristic of vertical axis machines (California Energy Commission 1993).

Clothes Dryers

With current natural gas and electricity prices in California, natural gas dryers are far less expensive to operate. For a typical load, a natural gas dryer costs approximately $0.12 to operate, while an electric dryer costs approximately $0.53. Other than fuel type, the major energy consideration is whether the dryer has sensing mechanisms that turn it off when the clothes are dry. The most efficient dryers have moisture sensors in the drum, while others only infer dryness by sensing the temperature of the exhaust air. Compared to timed drying, you can save about 10 percent in energy costs with a temperature-sensing control, and 15 percent with a moisture-sensing control (Wilson and Morrill 1997).

Water Heaters. Next to space heating and cooling, water heating is typically the next largest energy expense in the home (ACEEE 1996). The following are measures homeowners can take to reduce energy used for water heating (ACEEE 1996):

1. Install low flow showerheads to reduce the amount of hot water used. Federal efficiency standards require all new showerheads to have a maximum flow of 2.5 gallons per minute (gpm). Many older showerheads typically deliver 4-5 gpm.

2. Insulate the water heater. On older water heaters, an insulation jacket can reduce the heat loss through the walls by 25-40 percent, which saves 4-9 percent on water heating bills. Insulating a water heater can pay for itself through energy savings in

less than a year. Even new models that come with fairly high insulation can benefit from more insulation, though the payback period will be longer.

3. Install heat traps or one-way valves on both the hot and cold water lines. Without heat traps, hot water rises and cold water falls within the pipes, allowing hot water from the tank to rise into the house pipes and cold water from the main line to flow into the water heater. These devices cost approximately thirty dollars and will save between fifteen and thirty dollars a year, giving a payback period of one to two years.

When replacing a water heater it is important to compare models using the Energy Guide Label. Since May 1980 all new storage tank water heaters sold in the United States must have this label (Krigger 1994), which allows comparison shopping between models.

An alternative to storage tank water heaters is the instantaneous or demand water heater. Instantaneous water heaters heat the water only when there is a demand for it, therefore eliminating any stand-by heat loss that occurs with a storage tank water heater. In a storage tank water heater most of the heat from the pilot light goes into the tank; in an instantaneous water heater this energy is wasted. An energy efficient storage tank unit costs approximately $145 a year to run (based on $0.60/therm for natural gas, in a household of four) while an instantaneous unit costs approximately $140 a year to run (Wilson and Morrill 1997). Thus, the two types of water heaters use a comparable amount of energy. However, a new forty-gallon energy-efficient storage tank water heater costs approximately $350 while an instantaneous water heater costs approximately $600. Thus, unless the cost of instantaneous water heaters come closer to the price of storage tank water heaters they will not be a cost effective investment.

CHAPTER 4

PROGRAM DESIGN

Overview

The goal of this thesis was to make climate-dependent energy efficiency recommendations for any location in California. This was accomplished using the Geographic Information Systems (GIS) program, ArcView (ESRI 1996) and the spreadsheet program, Excel (Microsoft 1994). ArcView works in layers or themes, allowing many different data bases to be overlaid. The layers that were used in CREST consisted of geographical information such as the state of California, counties, roads and towns etc. Other layers were developed for CREST on Excel including a grid overlaid onto California, weather interpolation for each grid, and recommendations for each grid. These geographical layers allow users to locate their homes and receive recommendations based on their actual location.

The following chapter discusses the sources of data, the development of the grid, how the weather was interpolated, and how ArcView and Excel were utilized in developing CREST.

Data sources and analysis

Data

Climate data used for CREST was purchased from the National Climatic Data Center (NCDC). NCDC receives and processes data from 243 weather stations in California. The climate data used for this program were:

- Summer high temperatures
- Summer lows temperatures
- Winter highs temperatures
- Winter lows temperatures
- Summer wet bulb temperatures
- Heating degree days
- Cooling degree days

Information about the effectiveness and performance of appliances under different climatic conditions came from governmental sources, public interest groups and groups that have performed contracted work for government agencies. They include the following: United States Department of Energy (DOE), California Energy Commission (CEC), Davis Energy Group, Energy Efficiency and Renewable Energy Clearinghouse, American Council for an Energy Efficient Economy (ACEEE) and the Florida Solar Energy Center. General energy saving recommendations that are not climate related came from these sources as well.

Data compilation

Climate data from the 243 weather stations were entered onto an Excel spreadsheet. Latitude and longitude identified the location of each weather station. The weather stations were numbered 1-243. The actual location by latitude and longitude and the number identification were utilized for interpolating the climate for each section.

Appliances were recommended based on interpolated climate data for each section. Passive solar overhang dimensions were calculated using the latitude of the center of each section of the grid. The data required for making recommendations on appliances or retrofits are illustrated in table 3.

Table 3. -Data required for recommendations

Recommendations for:	Data required:
Evaporative coolers	Summer wet bulb temperatures Summer high temperatures
Whole house fans	Summer high temperatures Winter low temperatures
Heat pumps	Winter low temperatures
Ceiling fans	Summer high temperatures
Insulation levels	Heating degree days Cooling degree days
Overhang dimensions	Longitude

For either a single stage or a dual stage evaporative cooler to be recommended, summer highs needed to be 82°F or greater. If temperatures were greater than 82°F, the temperature that the evaporative cooler supplied needed to be 73°F or less. This depends on the high temperature and the humidity. To figure the air supply temperature the following formula was used (Watt 1986):

$$\text{Tsupply} = 0.2\ \text{TDBout} + 0.8\ \text{TWBout}$$

Where the variables are defined as follows:
Tsupply = temperature of air supplied by cooler to the home, °F
TDBout = outdoor dry-bulb temperature, °F
TWBout = outdoor wet-bulb temperature, °F

If the air supply temperature for the single stage evaporative cooler was greater than or equal to 73°F, the formula was used again to determine the air supply temperature for a dual stage evaporative cooler. The supply temperature from the single stage evaporative cooler calculation replaces the outdoor dry-bulb temperature for the new calculation but, the wet-bulb temperature remains the same since the first stage of a dual stage evaporative coolers does not add humidity to the air. If the dual stage evaporative cooler could not supply air less than or equal to 73°F, than an air conditioner was recommended for cooling.

Whole house fans were recommended if the summer highs were greater than 82°F and the ambient evening temperatures fall below 73°F for at least one month

(Department of Energy 1989). All sections with summer highs over 82°F met this requirement.

Air to air heat pumps were recommended when winter lows did not fall below 32°F. In areas with lows below 32°F, geothermal heat pumps were recommended (Department of Energy 1989). These recommendations would only be used if the customer does not have natural gas or propane available to them.

Ceiling fans were recommended in sections that had highs above 82°F (Wilson and Morrill 1997). They could be used at lower temperatures but due to the difficulty in installing them, temporary floor fans would be a better option.

Attic insulation levels were recommended based on heating and cooling degree-days (California Energy Commission 1995). Table 4 indicates the number of degree-days required for each recommendation.

Table 4. -Insulation levels

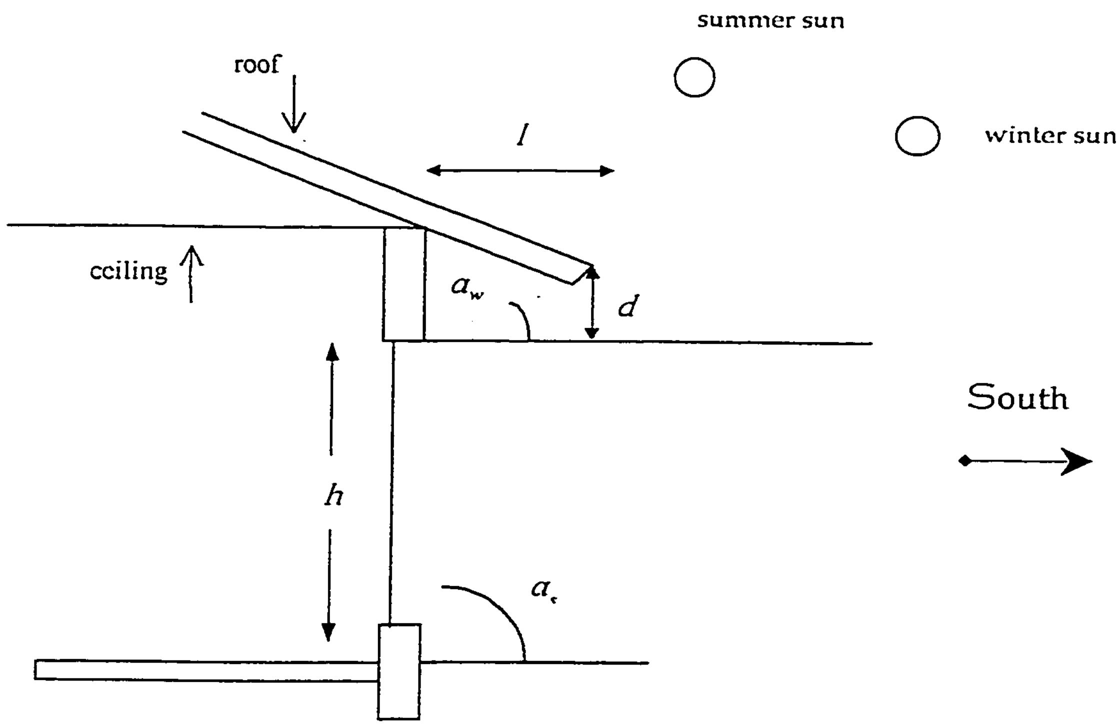
Insulation Levels	Heating and cooling degree days combined
R-19	Less than 3000 degree days
R-30	3000-5000 degree days
R-38	More than 5000 degree days

Source: California Energy Commission, Energy Efficiency Standards for Residential and Nonresidential Buildings, (Sacramento: Publications Office, 1995), 47.

Overhang dimensions for south-facing walls (see fig 1), which can be used for roofs, awnings or trellises, were figured from the equation (Niles and Haggard 1980):

$$l = \frac{h}{\tan a_s - \tan a_w} \quad \text{And} \quad d = l \tan(a_w)$$

Figure 1 Passive solar overhangs



Source: Niles, Philips W.B., and Kenneth L. Haggard. Passive Solar Handbook. (Sacramento: California Energy Commission 1980), 62.

Where the variables are defined as follows:

h = height measured from the floor to the top of glazing. This will be seven feet, which is the industry standard.
a_s = 102 – latitude. This will allow for 70 percent shading until August 20th (Barnes 1998).
a_w = the winter noon altitude angle.
d = the difference in height from the top of the glazing to the lowest point of the overhang.
l = Length of overhang from the house.

Analysis

California was divided into a grid comprised of 643 sections. Climate data from weather stations throughout the state were used to interpolate weather data for each section of the grid. From this interpolated weather data, recommendations that are climate dependent were matched with each section. The latitude from the center of each section was used to calculate passive solar overhangs.

California was divided into a grid based on latitude and longitude lines. The grid sections for CREST are one-fourth degree latitude by one-third degree longitude. This produced sections that range from eighteen by eighteen miles at the southern border to eighteen by seventeen miles at the northern border of the state, for a total of 635 sections. Each section was characterized by the latitude and longitude of its center.

After the centers were located for each section, the distance to each climate station from each center was calculated. This was accomplished by using the Pythagorean Theorem on an Excel (Microsoft 1994) spreadsheet.

$$C^2 = A^2 + B^2 \ ^{*}$$

C = distance in miles from the weather station to center of section
A = change in longitude degrees x 52.5 miles/1 degree longitude
B = change in latitude degrees x 73 miles/1 degree latitude

When the distances from each of the centers to all the weather stations were determined, the three closest were identified. Excel (Microsoft 1994) was used to calculate the three closest weather stations to each center using a true/false statement. For example, if the distance was greater than fifty miles, a false answer was produced. If there were too many true responses, a shorter distance was utilized until only three true responses remained.

After the three nearest climate stations were determined, climate variables for each section were interpolated using the following standard formula. This distance weighing formula gives more significance to the closest climate station.

$$T_s = \frac{T_1/d_1^2 + T_2/d_2^2 + T_3/d_3^2}{1/d_1^2 + 1/d_2^2 + 1/d_3^2}$$

T_s = interpolated climate variable of section
T_1, T_2, T_3 = climate data from three closest climate stations
d_1, d_2, d_3 = distance of three closest climate stations to center of section

* One degree of latitude is approximately seventy-three miles. The average length of one degree of longitude in California is 52.5 miles.

With the sections identified and the climate data for each section determined, climate parameters were established for the recommendations. The climate data from each center was matched to the climate parameters of each appliance on an Excel (Microsoft 1994) spreadsheet using a true/false statement. When the centers climate matched the appliance requirement a true response was given. Recommendations were thereby generated on Excel (Microsoft 1994) creating a layer on ArcView. This layer was then combined with the grid layer by ArcView so that when the user of the program chooses a section, recommendations are given.

Table 5 is an overview of the layers used in ArcView (ESRI 1996) to produce a map on which user could located their home.

Table 5. -ArcView layers

User selects section with assistant of these layers	
Layers	Geographical points of interest
	State and US routes
	CREST's grid
	California's 58 counties
	Map of California
Results	Efficiency Recommendations

Starting with a map of California, a layer of California's fifty-eight counties was added. Overlaid on this was the grid, using the longitude and latitude of the centers. The grid was added as a layer using Avenue (ESRI 1996), ArcView's (ESRI 1996) programming language. State and US routes were added statewide. Geographical data points were added section by section, so that each section had several recognizable features. In densely populated areas, cities were used. In sparsely populated areas various indictors were used including schools, ranches, airports, historical buildings, etc. These data were selected from an existing database available from ESRI and were added as individual layers. Table 6 shows the number of data points selected from the existing database for each layer.

Table 6. –Data points

Data Base	Data Points Available	Data Points Utilized
Schools	8198	43
Local Points (Ranches, parks, airports, government buildings)	10312	131
Gazetteer Points (Mountains, unincorporated populated places)	61	10
Towns	5931	1184
Total	24502	1368

User Interface

The user is given a list of California counties to choose from. When the county is identified, a map of that county, overlaid with the grid is displayed. Geographical points such as cities, airports, schools and highways appear. The user needs to identify the section in which their home is located. Recommendations for that section are then displayed on the screen.

Other applications

While CREST is currently only for use in California, the software can be relatively easily adapted for other states using climatic zone data for that state. Climate data from NCDC is available for all fifty states. A grid system similar to the one used in CREST could be constructed for each state. The climate ranges for the cooling appliances would be the same state by state. Most of the general energy efficiency data, for example for lighting, would remain the same. Additional data on appliances not commonly used in California, such as boilers, might be needed.

Chapter 5

RESULTS

The results are quite varied throughout the state. Table 7 shows a sample of recommendations for several cities. Of the 635 sections, 122 sections required no mechanical cooling and 498 sections could be adequately cooled by evaporative coolers. Of those 498 sections, only 58 would require a dual-stage evaporative cooler. Only fifteen sections could not have their cooling needs satisfied by evaporative coolers and would require an air conditioner. Table 8 shows the number of sections in which each appliance was recommended.

Table 7. –Sample of Recommendations

City	Cooling*	Heat Pump	Attic Insulation	Overhang Dimensions**	
				l	*d*
Eureka	None	Air to air	R-30	63"	30"
Truckee	CF	Geothermal	R-38	59"	30"
Sacramento	SSEC,WHF,CF	Air to air	R-30	57"	30"
Palm Springs	DSEC,WHF,CF	Geothermal	R-38	45"	29"
San Diego	None	Air to air	R-19	43"	28"

*CF-ceiling fan
SSEC-single-stage evaporative cooler
DSEC-dual-stage evaporative cooler
WHF- whole-house fan
** See Figure 1

Table 8. – Appliance recommendations

Recommendations	Number of Sections Recommended
Single-stage evaporative cooler	440 (69%)
Dual-stage evaporative cooler	58 (9.1%)
Air conditioner	15 (2.3%)
Air to air heat pump	429 (67.5%)
Geothermal heat pump	206 (32.5%)
Whole house fan	514 (80.9%)
Ceiling fans	543 (85.5%
Shade trees	514 (80.9%)
R-19 Attic insulation	42 (6.6%)
R-30 Attic insulation	301 (47.4%
R-38 Attic insulation	292 (45.9%)

Conclusion

Because of its size, location, and varied topography, California has a wide range of climates. This makes selecting residential energy efficiency options difficult. This thesis interpolated California's climate and matched appliance, passive solar overhangs, and insulation recommendations to each section. The most significant finding of this thesis was that nearly 80% of California's climate is suitable for evaporative coolers. Most of California could be adequately cooled using low energy consuming evaporative coolers rather than high energy consuming air conditioners. This represents a significant savings potential that has been neglected in prior work. If these guidelines were followed, significant amounts of energy could be saved in the residential sector.

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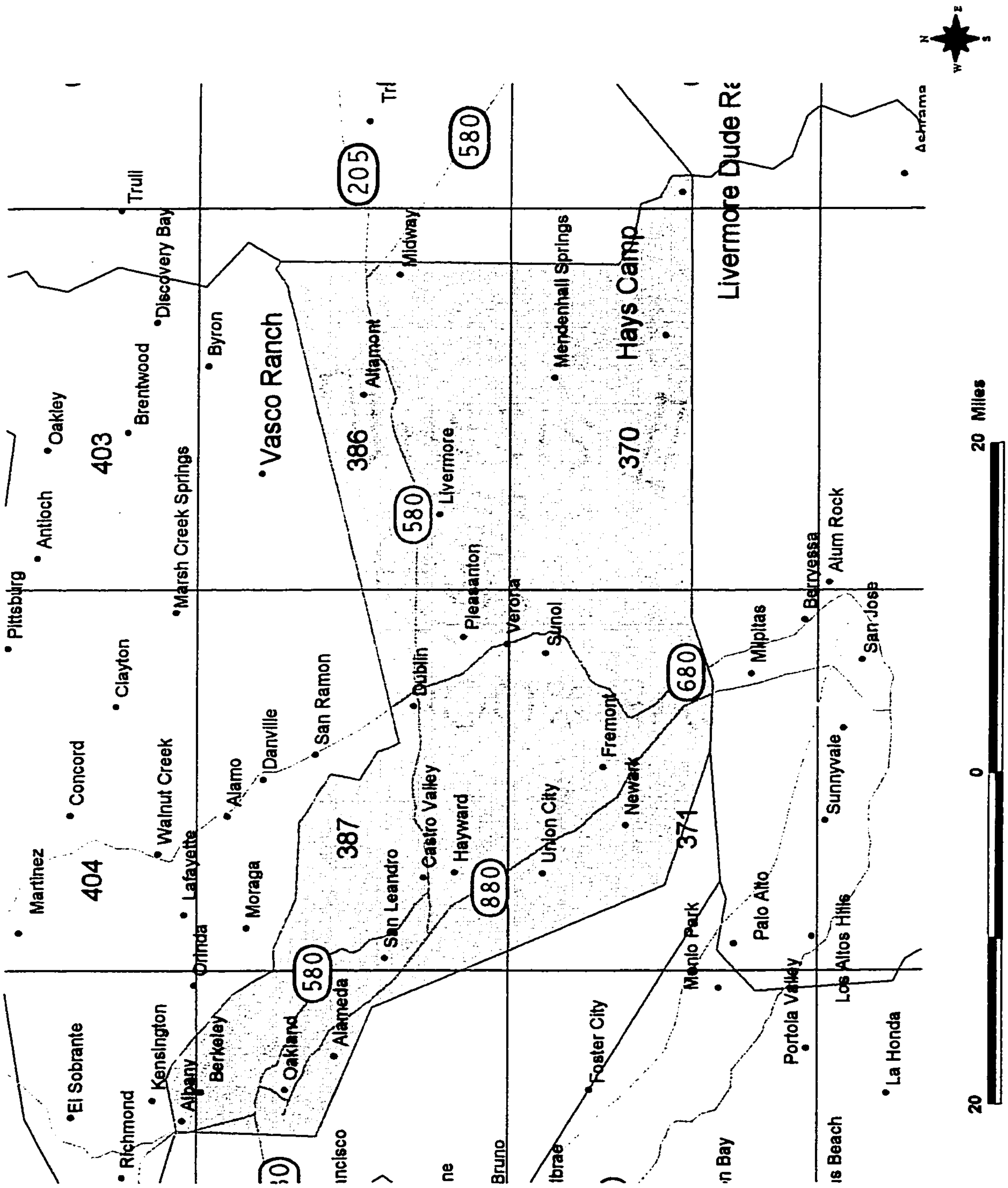
APPENDIX A

1) Locate the county in Appendix A. Note the number of the grid section. Find the correlating number in Appendix B for recommendations for that section.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Lafayette
Orinda
Moraga
Alamo
Danville
San Ramon
Dublin
Pleasanton
Livermore
Altamont
Midway
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Mendenhall Springs
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Livermore Dude R
Verona
Sunol
Fremont
Newark
Union City
Hayward
Castro Valley
San Leandro
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Berkeley
Albany
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El Sobrante
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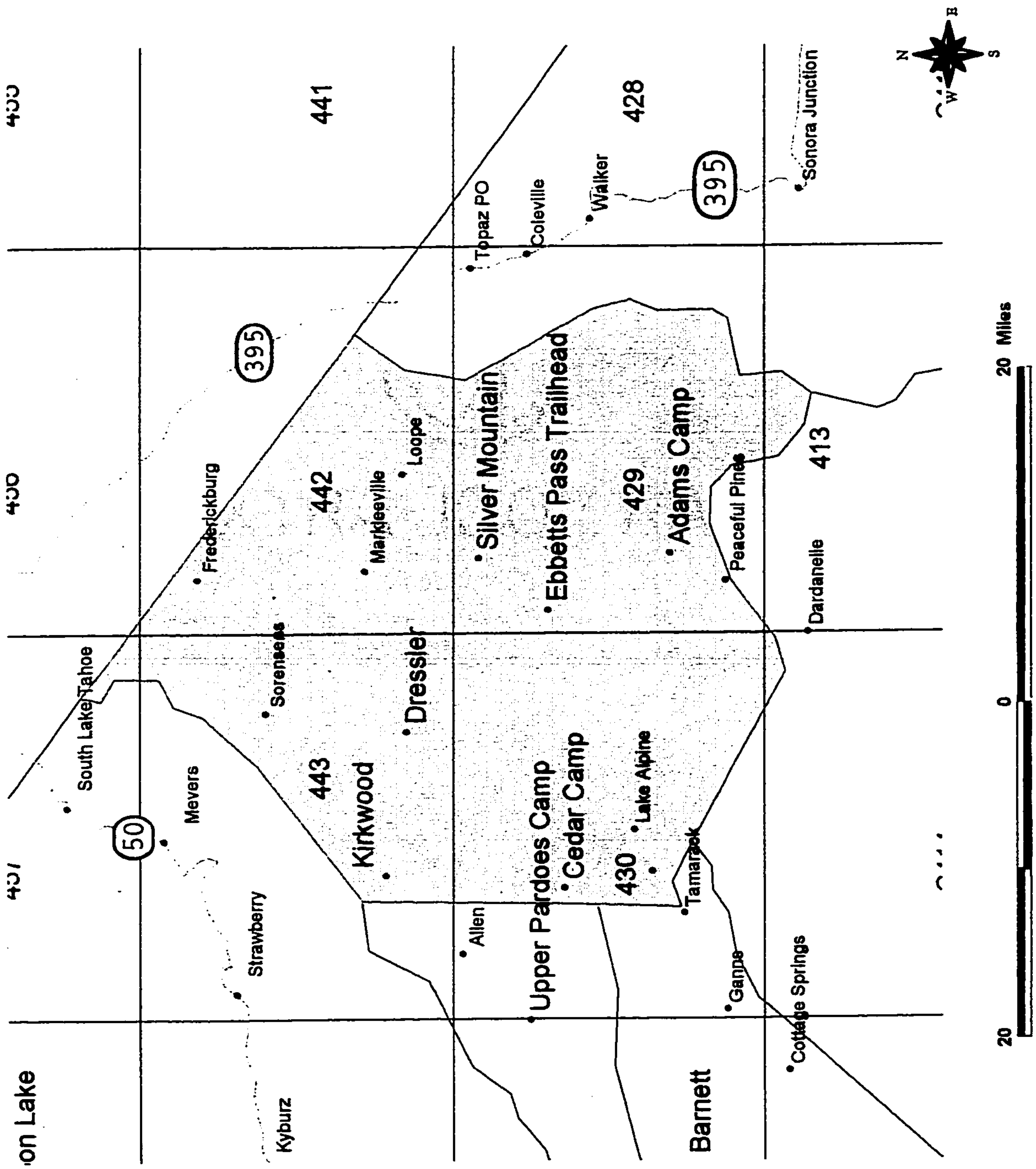
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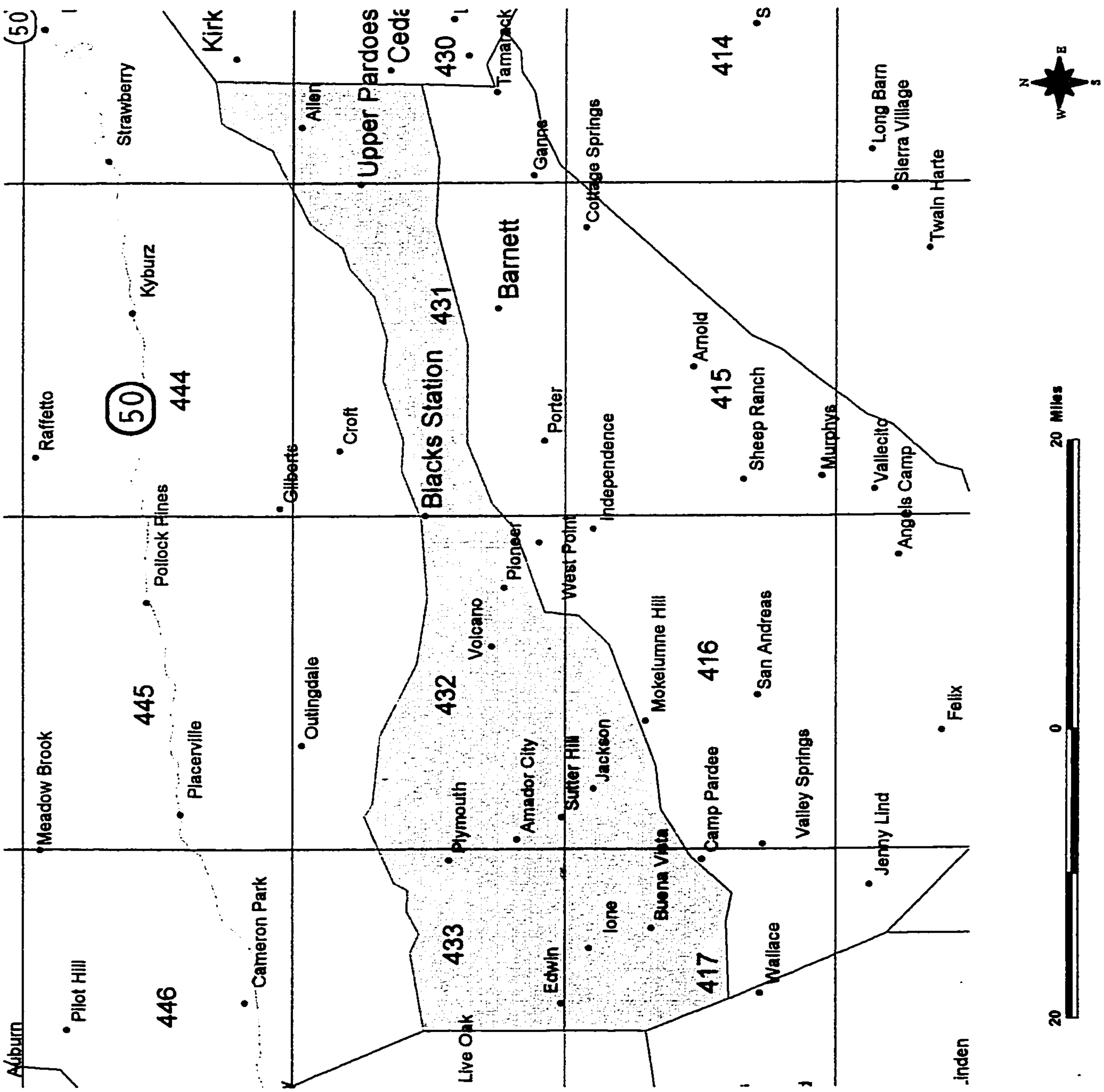

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Ganns
Cottage Springs
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Gilberts
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Pioneer
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Porter
Independence
Arnold
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Sheep Ranch
Murphys
Vallecito
Angels Camp
Long Barn
Sierra Village
Twain Harte
Mokelumne Hill
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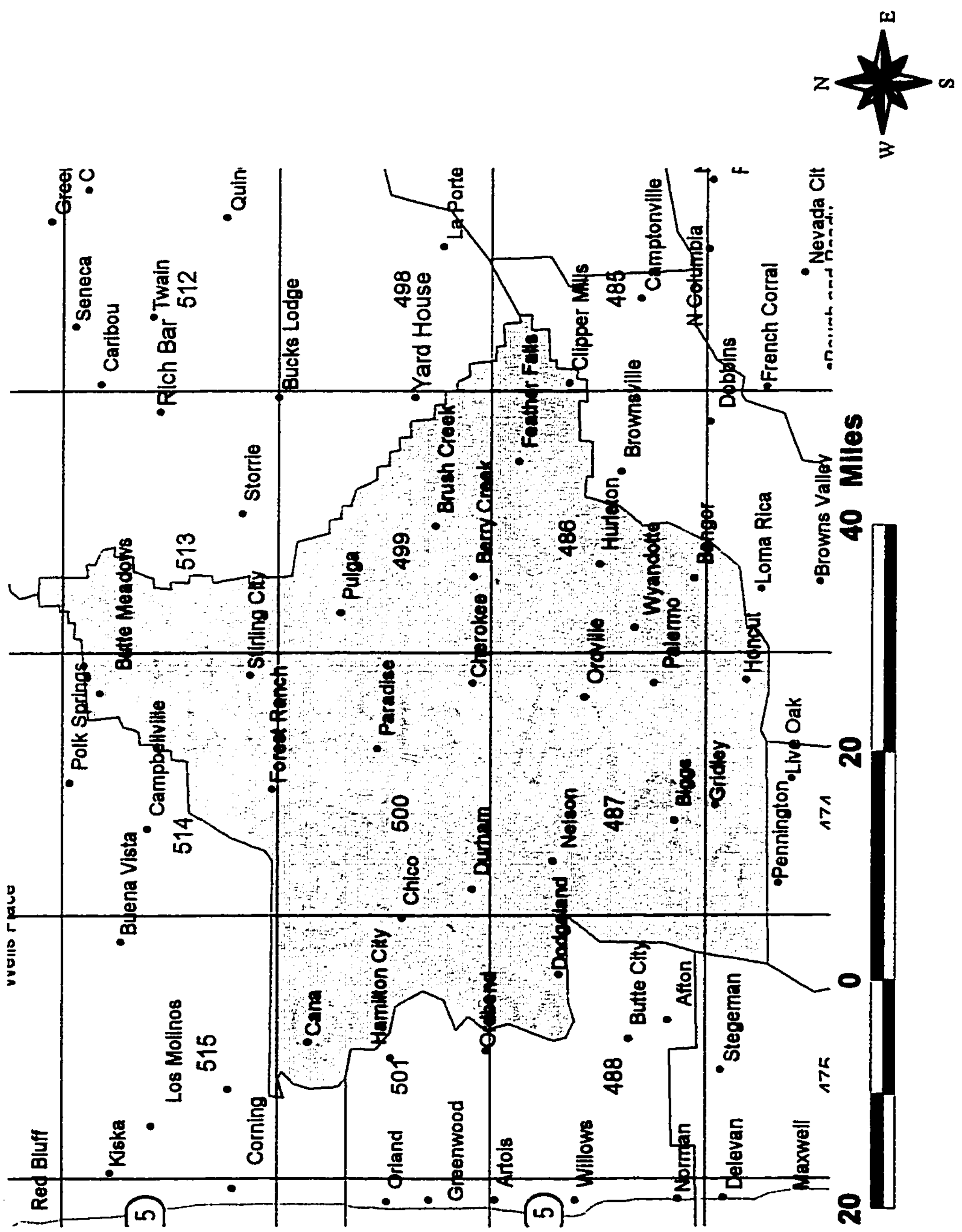
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Chico
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Orland
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Artois
Paradise
Pulga
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Yard House
498
La Porte
Brush Creek
Berry Creek
Cherokee
Durham
Ord Bend
Dodgeland
Nelson
487
Oroville
486
Feather Falls
Clipper Mills
485
Camptonville
Brownsville
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Palermo
Biggs
Gridley
Willows
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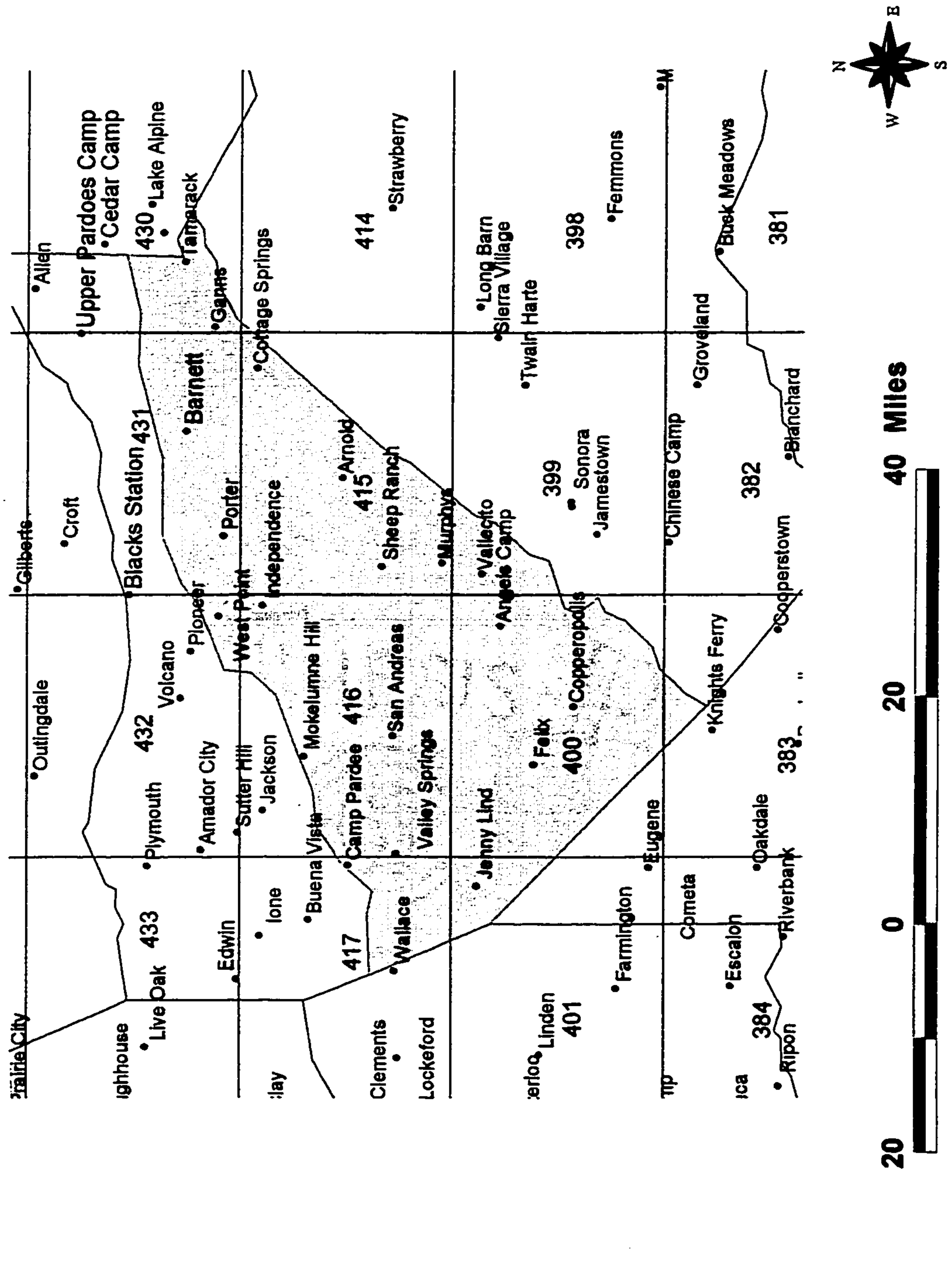

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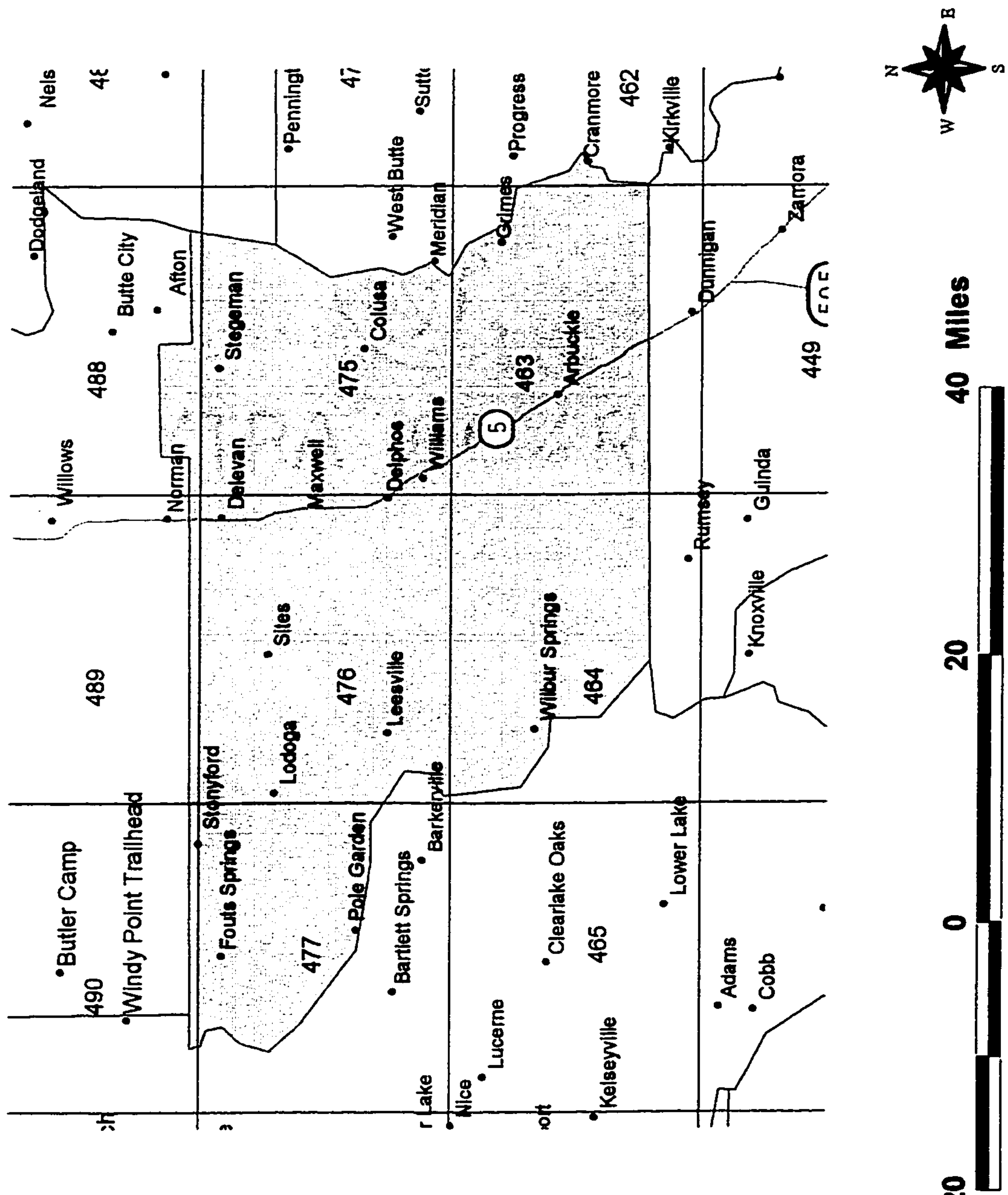
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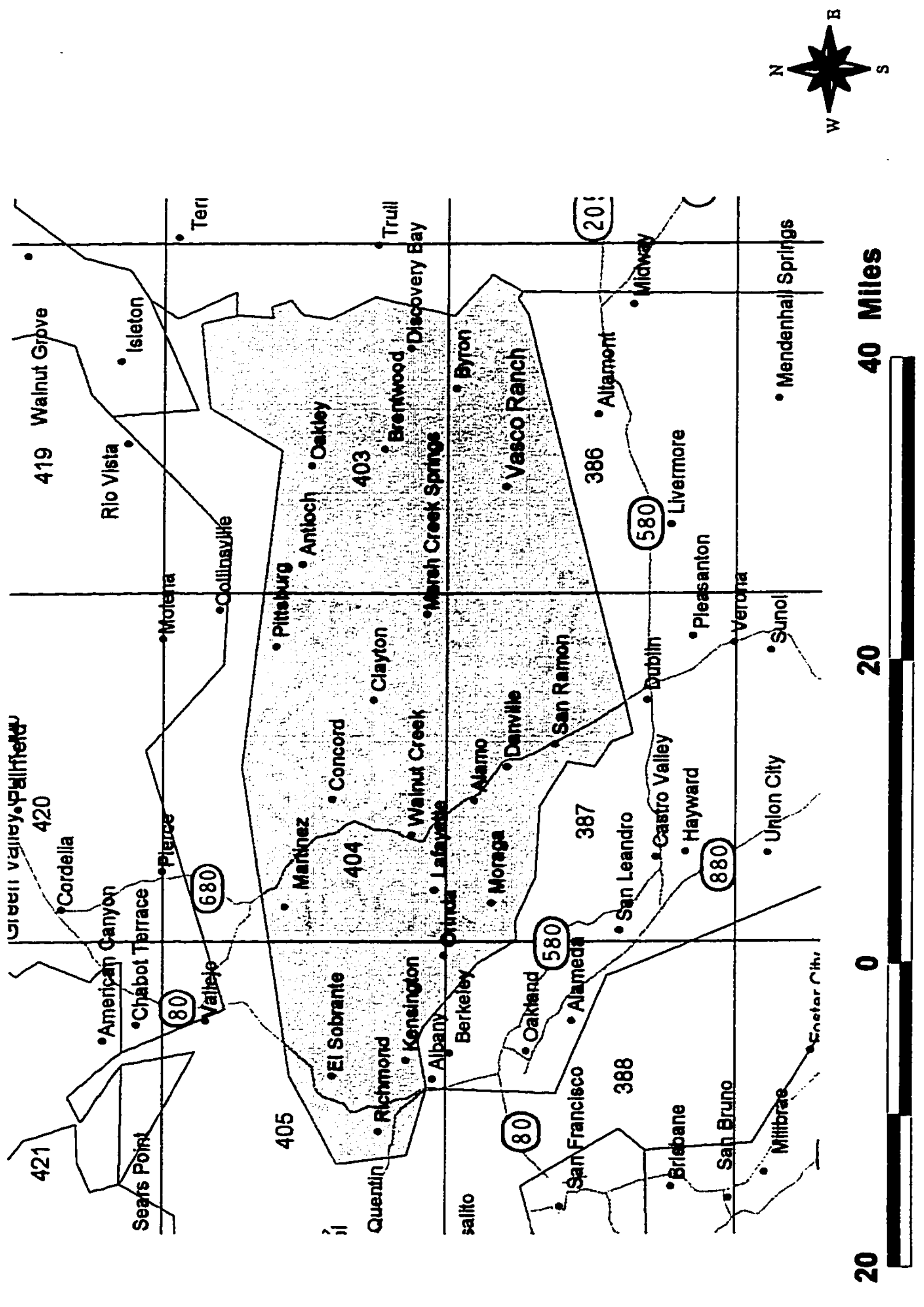
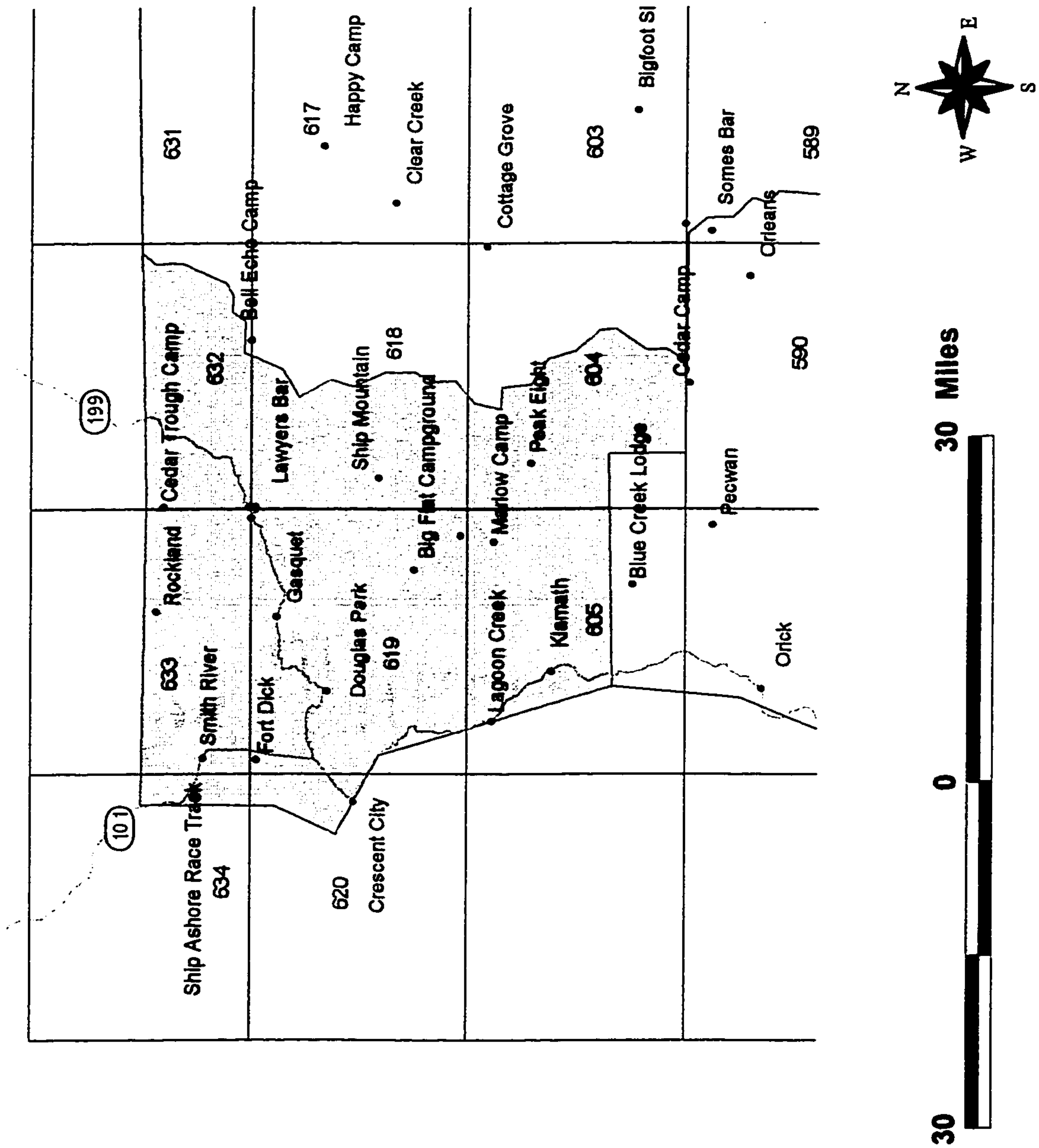
489
490
Butler Camp
Windy Point Trailhead
Pennington
West Butte
Meridian
Sutter
Progress
Grimes
Cranmore
462
Kirkville
Stegeman
Colusa
475
Delevan
Maxwell
Delphos
Williams
5
463
Arbuckle
Dunnigan
Zamora
449
Rumsey
Guinda
Knoxville
Sites
476
Leesville
Wilbur Springs
464
Lodoga
Stonyford
Fouts Springs
Pole Garden
477
Bartlett Springs
Barkerville
Clearlake Oaks
465
Lower Lake
Adams
Cobb
Lucerne
Nice
Kelseyville
N
E
S
W
40 Miles
20
0
20

Contra Costa Co



Del Norte Co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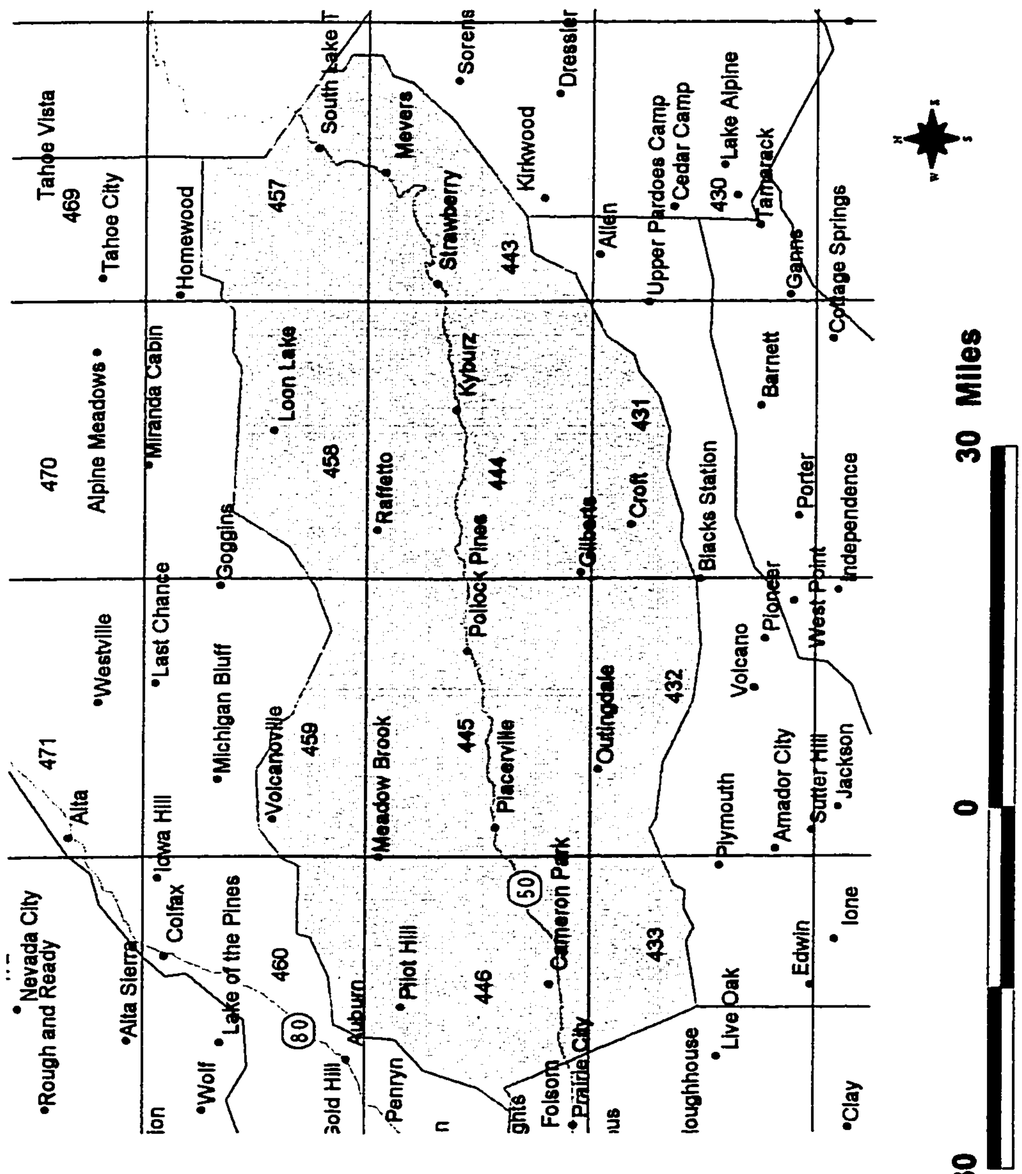
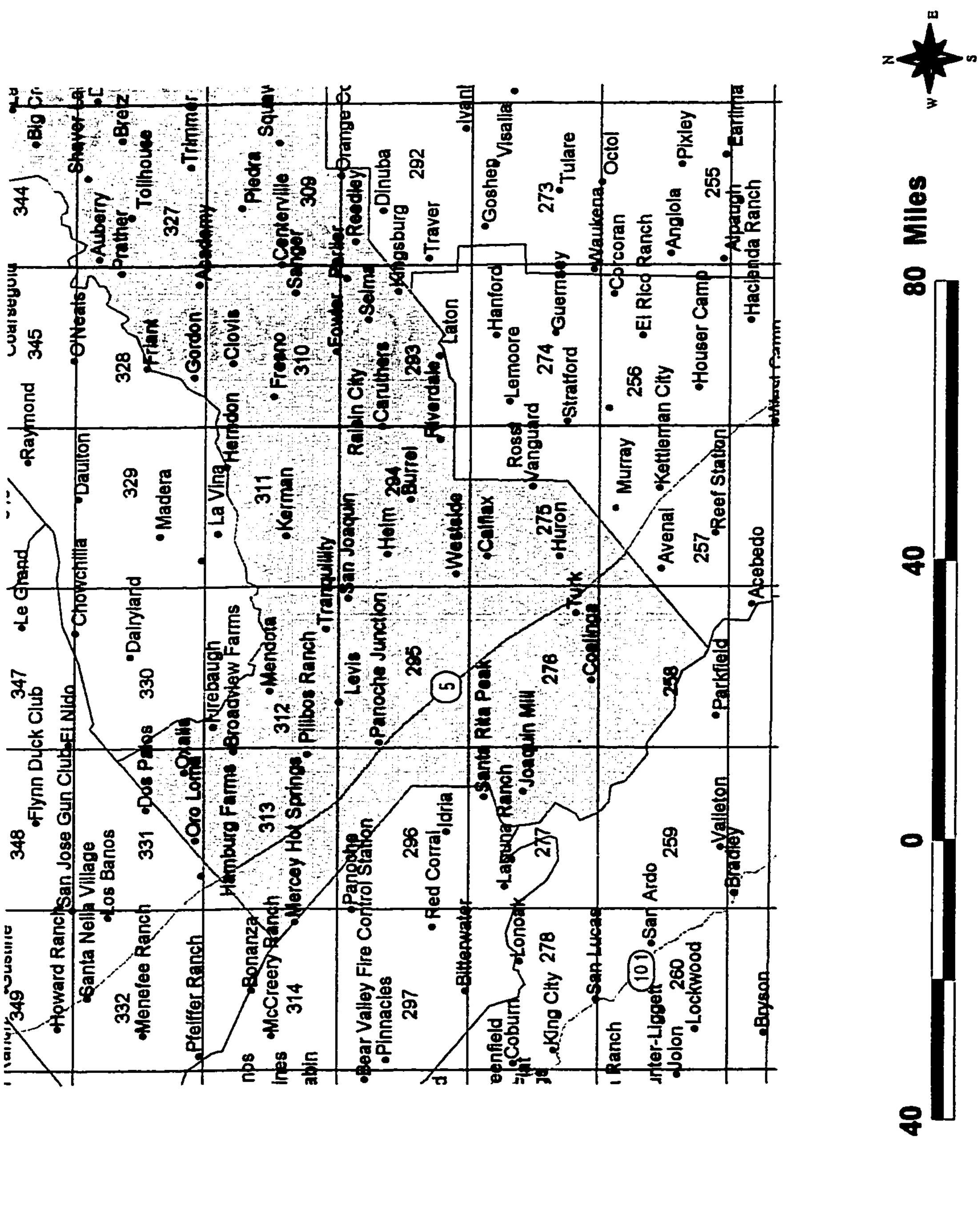
632
633
634
617
618
619
620
603
604
605
590
589
199
101
Happy Camp
Clear Creek
Cottage Grove
Bigfoot Sl
Somes Bar
Orleans
Cedar Camp
Bell Echo Camp
Cedar Trough Camp
Lawyers Bar
Ship Mountain
Big Flat Campground
Marlow Camp
Peak Eight
Blue Creek Lodge
Pecwan
Rockland
Gasquet
Douglas Park
Lagoon Creek
Klamath
Orick
Smith River
Fort Dick
Crescent City
Ship Ashore Race Track
N
E
S
W
30
0
30
Miles

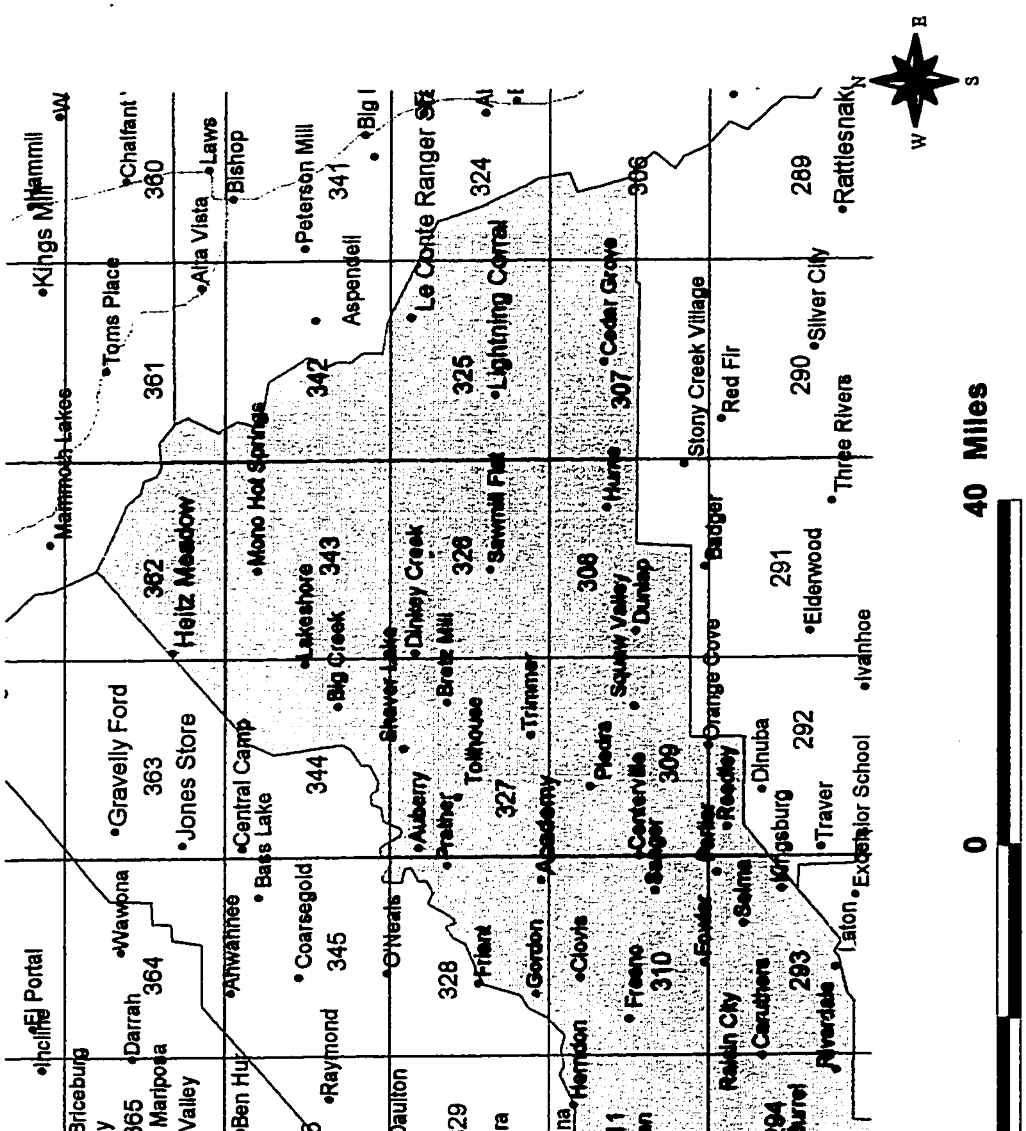
El Dorado Co

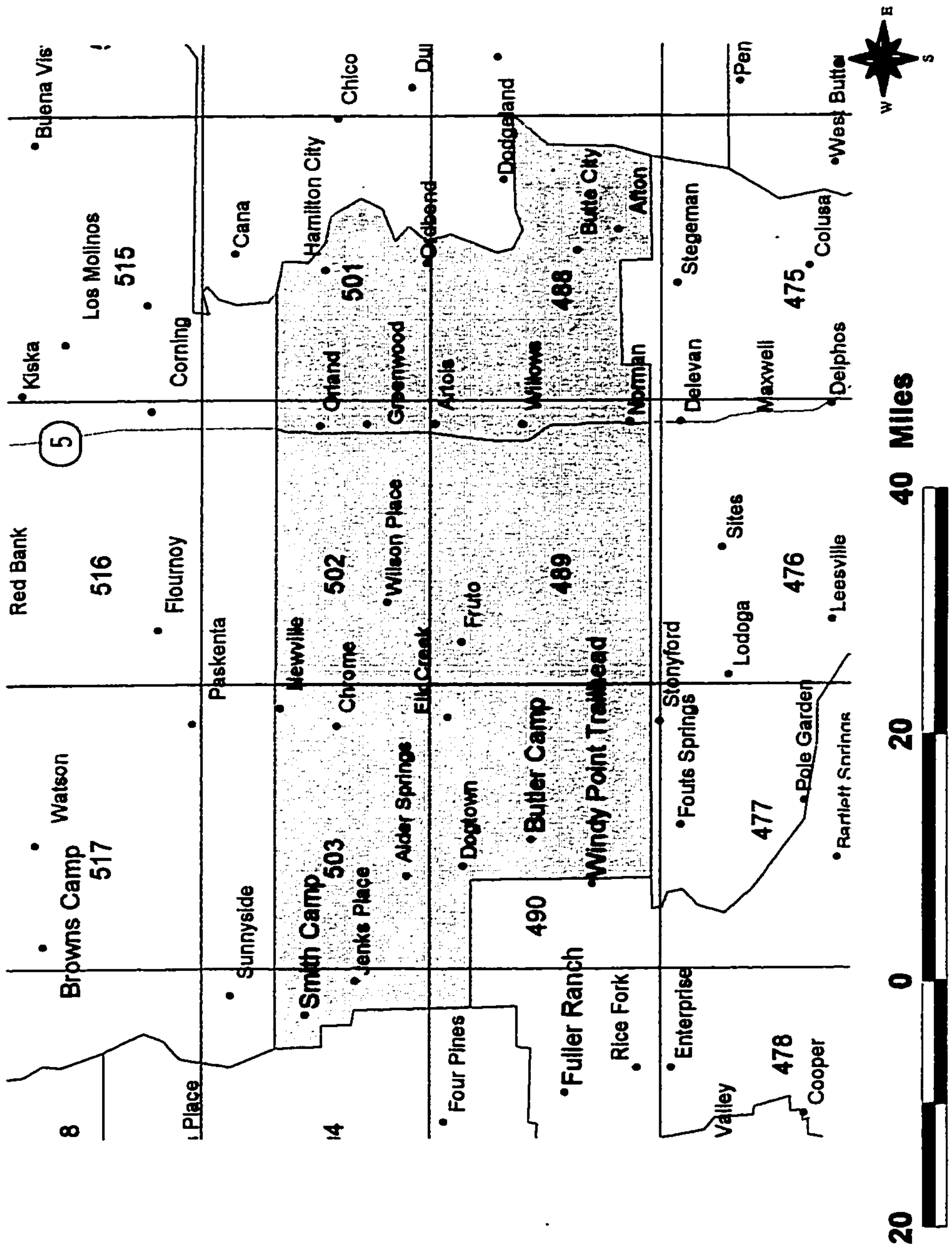

Tahoe Vista
469
Tahoe City
470
Alpine Meadows
Miranda Cabin
Homewood
457
South Lake T
Meyers
Sorens
Dressler
Kirkwood
Strawberry
443
Allen
Upper Pardoes Camp
Cedar Camp
430
Lake Alpine
Tamarack
Ganns
Cottage Springs
Loon Lake
458
Kyburz
Raffetto
444
431
Croft
Gilbert
Blacks Station
Barnett
Porter
Independence
West Point
Pioneer
Goggins
Last Chance
Westville
471
Alta
Michigan Bluff
Volcanoville
459
Meadow Brook
445
Pollock Pines
Placerville
Outingdale
432
Volcano
Amador City
Sutter Hill
Jackson
Plymouth
Iowa Hill
Colfax
Nevada City
Rough and Ready
Alta Sierra
Lake of the Pines
460
Wolf
80
Auburn
Pilot Hill
446
50
Cameron Park
433
Edwin
Ione
Live Oak
Clay
Penryn
Folsom
Prairie City
30 Miles
0
30

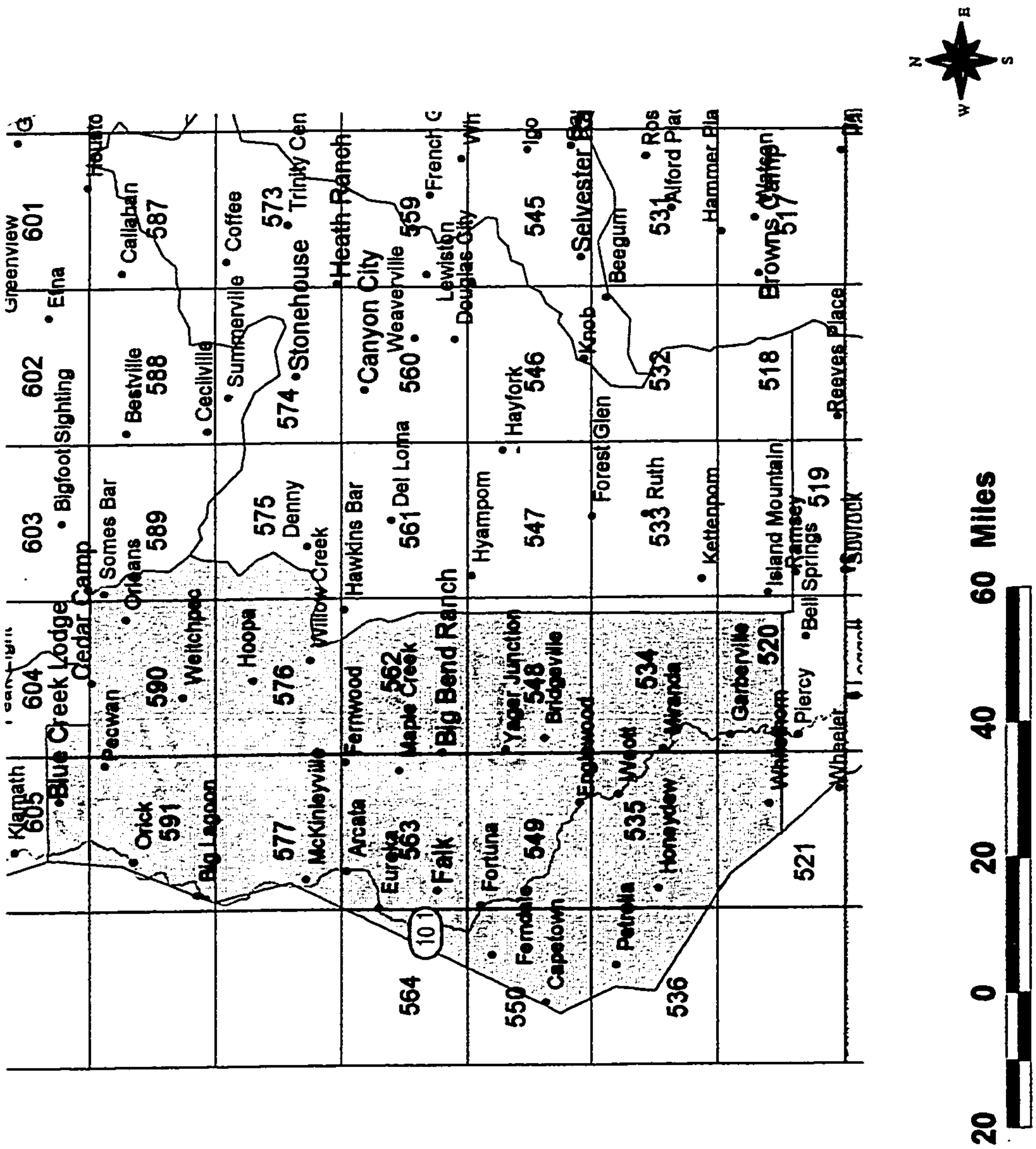
Fresno Co West

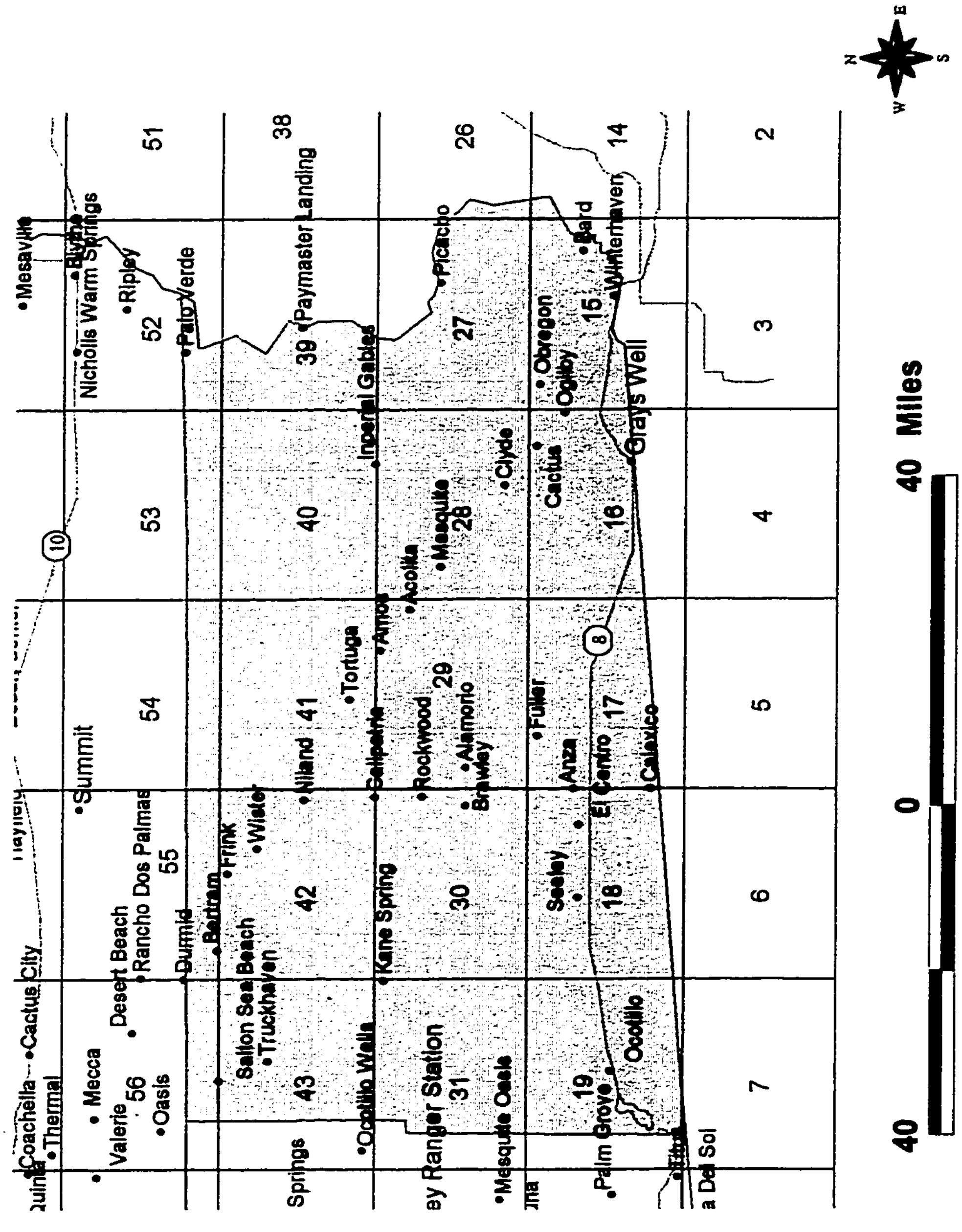


Fresno Co East

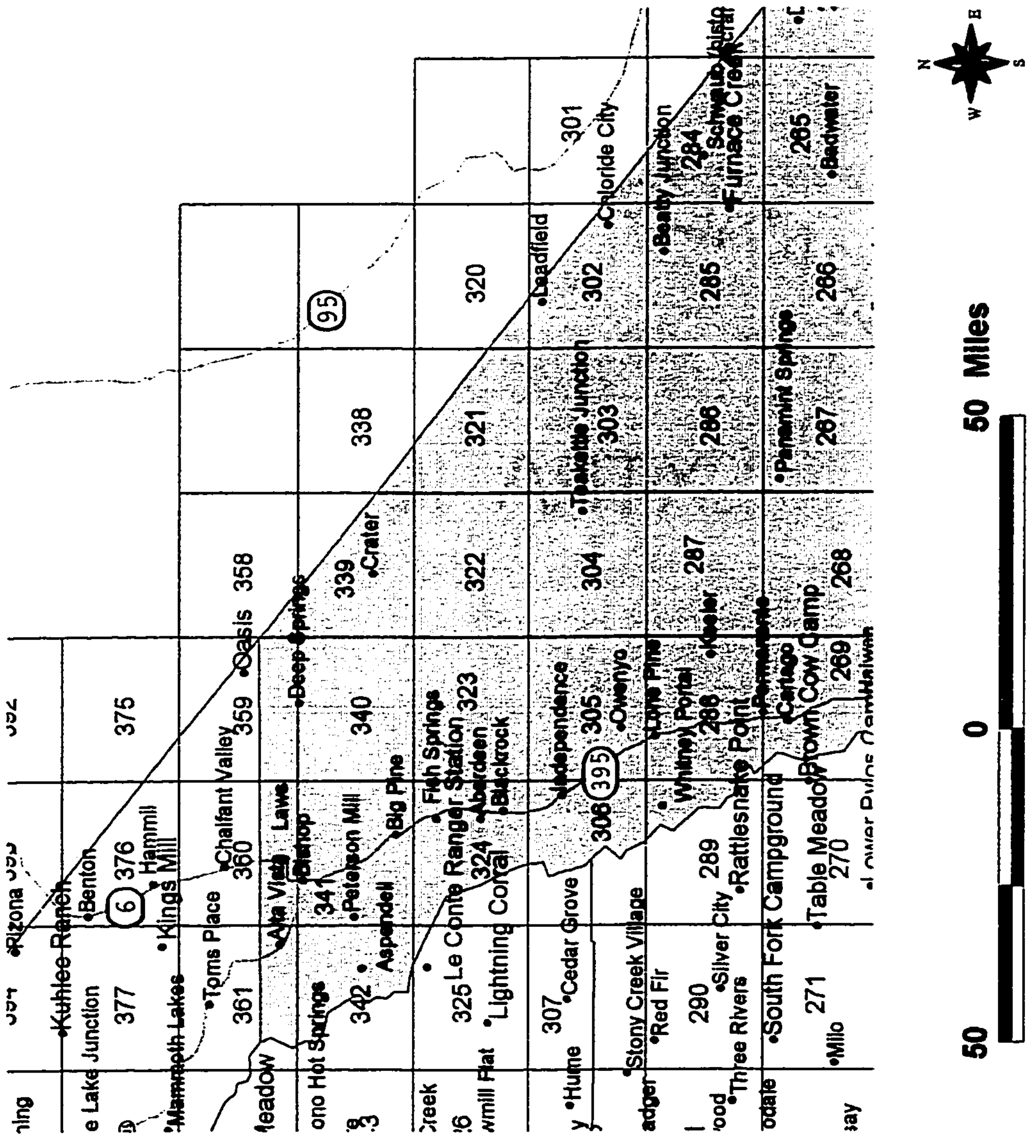



Buena Vis
Kiska
Los Molinos
515
Corning
Red Bank
516
Flournoy
Watson
Browns Camp
517
8
Place
Paskenta
Sunnyside
Cana
Hamilton City
Chico
501
Orland
Greenwood
Newville
502
Wilson Place
Chrome
Smith Camp
503
Jenks Place
Alder Springs
14
Elk Creek
Ordbend
Artois
Fruto
Dogtown
Four Pines
Dodgeland
Willows
488
Butte City
Afton
489
Butler Camp
Windy Point Trailhead
490
Fuller Ranch
Rice Fork
Norman
Stonyford
Fouts Springs
Enterprise
Stegeman
Delevan
Lodoga
Sites
476
477
Valley
478
Cooper
Maxwell
475
Colusa
Delphos
Leesville
Pole Garden
Bartlett Springs
Pen
West Butte
5
0
20
40 Miles
20

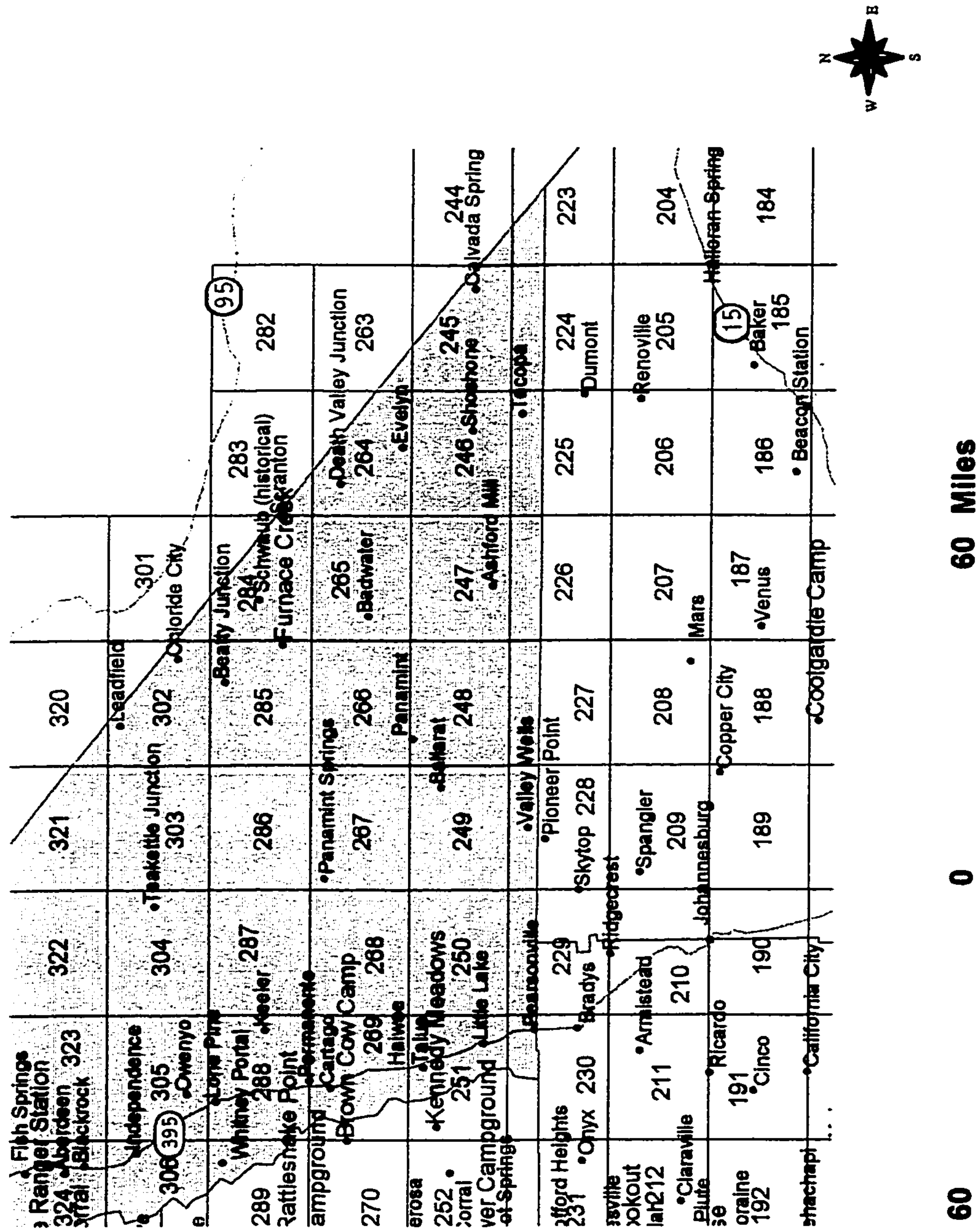

Klamath
Blue Creek Lodge
Cedar Camp
Pecwan
Orick
Big Lagoon
Orleans
Somes Bar
Weitchpec
Hoopa
Willow Creek
McKinleyville
Arcata
Eureka
Falk
Fernwood
Maple Creek
Big Bend Ranch
Fortuna
Ferndale
Capetown
Yager Junction
Bridgeville
Englewood
Weott
Miranda
Honeydew
Petrolia
Garberville
Whitethorn
Piercy
Bell Springs
Island Mountain
Kettenpom
Ruth
Forest Glen
Hyampom
Hayfork
Del Loma
Hawkins Bar
Denny
Canyon City
Weaverville
Lewiston
Douglas City
Stonehouse
Cecilville
Bestville
Summerville
Coffee
Callahan
Bigfoot Sighting
Etna
Greenview
Heath Ranch
Trinity Cen
Knob
Beegum
Selvester
Igo
Alford Pla
Hammer Pla
Browns Camp
Watson
Reeves Place
101
60 Miles
40
20
0
20

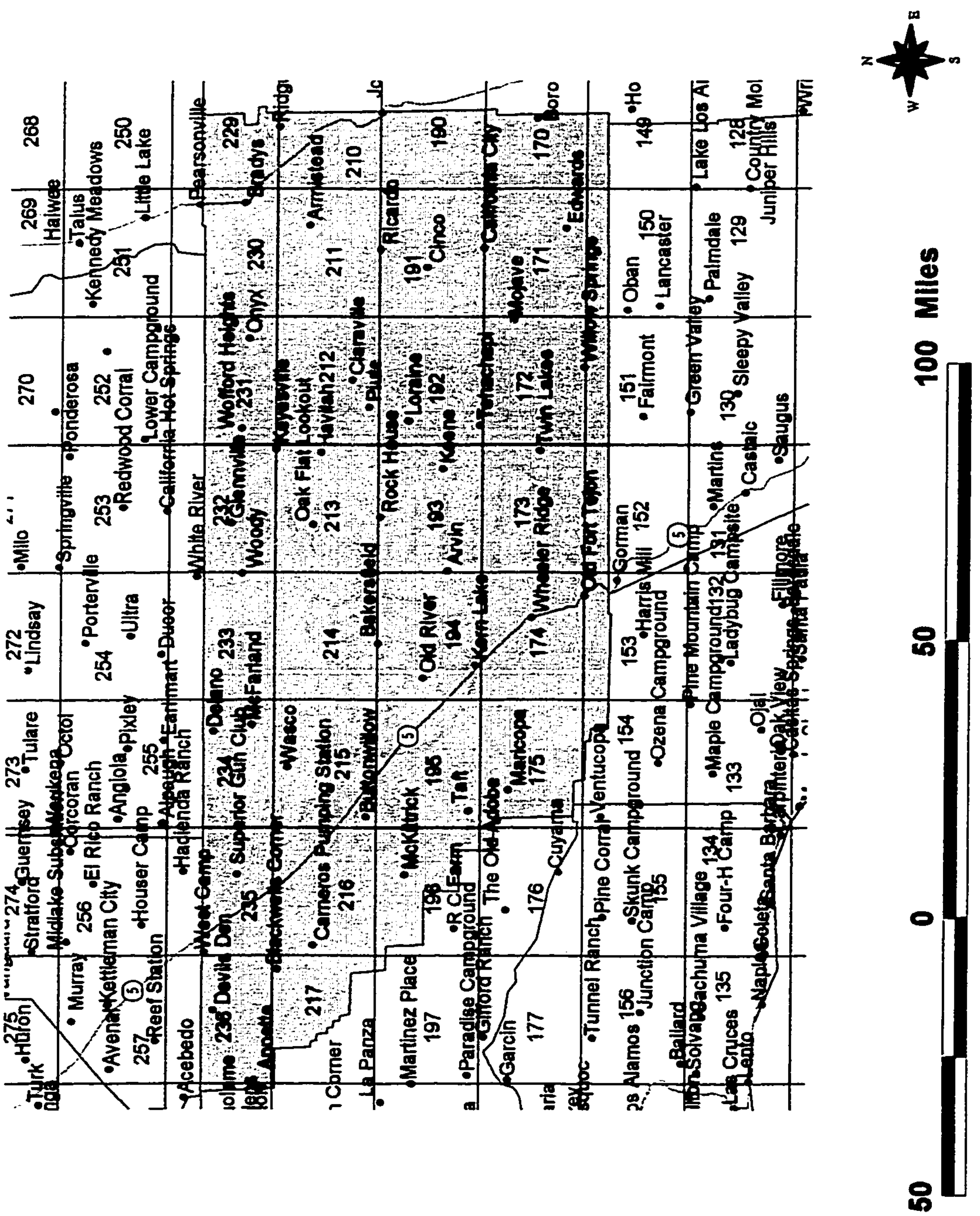

Mesaville
Blythe
Nicholls Warm Springs
Ripley
Palo Verde
Paymaster Landing
Picacho
Bard
Winterhaven
Obregon
Ogilby
Grays Well
Imperial Gables
Clyde
Cactus
Mesquite
Acolita
Amos
Tortuga
Calipatria
Rockwood
Alamorio
Brawley
Fuller
Anza
El Centro
Calexico
Summit
Rancho Dos Palmas
Desert Beach
Durmid
Bertram
Frink
Wister
Niland
Kane Spring
Salton Sea Beach
Truckhaven
Seeley
Ocotillo
Ocotillo Wells
Ranger Station
Mesquite Oasis
Palm Grove
Mecca
Valerie
Oasis
Coachella
Thermal
Cactus City
Springs
10
8
0
40
40 Miles
N
E
S
W

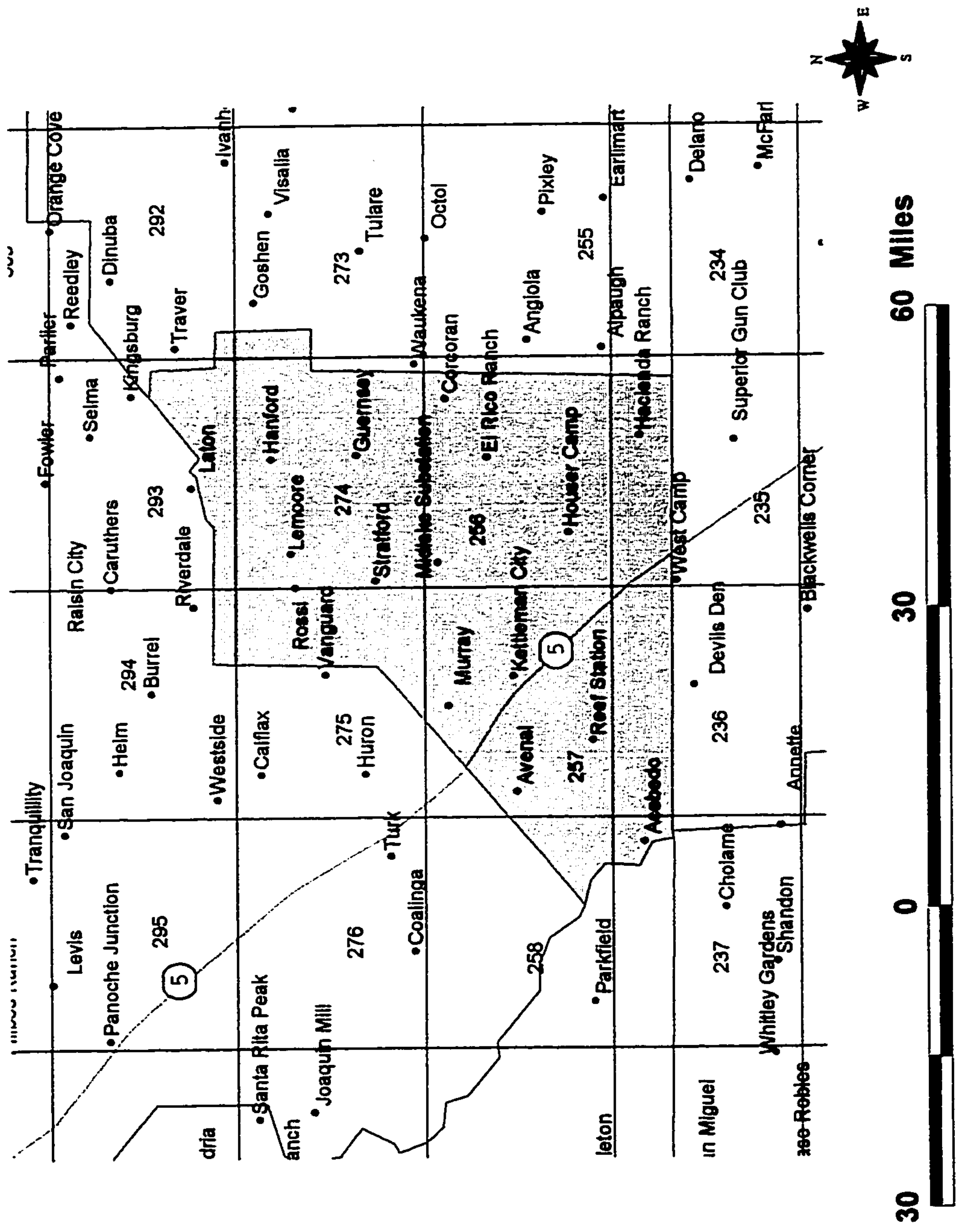
Inyo Co North



Inyo Co South

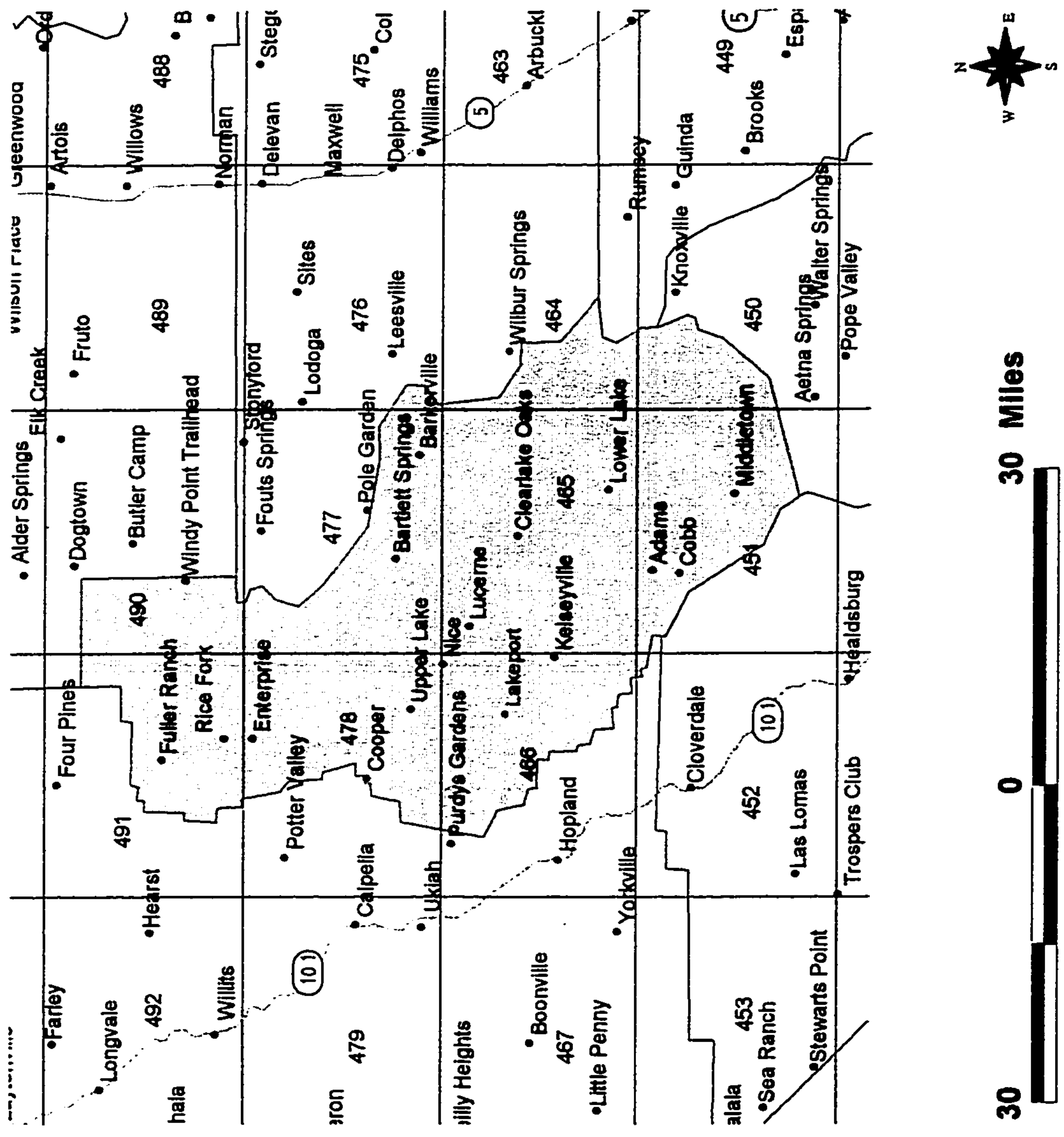



Bakersfield
Delano
Wasco
Taft
Arvin
Maricopa
Lamont
Tehachapi
Mojave
California City
Ridgecrest
Lancaster
Palmdale
Porterville
Lindsay
Tulare
Corcoran
Frazier Park
Shafter
Buttonwillow
Lost Hills
Keene
Loraine
Cinco
Ricardo
Edwards
Oban
Fairmont
Gorman
Lebec
Castaic
Saugus
Sleepy Valley
Green Valley
Willow Springs
Twin Lakes
Wheeler Ridge
Old River
McKittrick
Cuyama
Ventucopa
Ozena
Stratford
Guernsey
Kettleman City
Avenal
Huron
Alpaugh
Earlimart
McFarland
Pixley
Richgrove
Ultra
Ducor
California Hot Springs
Glennville
Woody
White River
Springville
Ponderosa
Redwood Corral
Kennedy Meadows
Little Lake
Onyx
Bodfish
Havilah
Oak Flat Lookout
Kernville
Rock House
Pearsonville
Armistead
Brady
Cantil
Lake Los Angeles
Juniper Hills
Country Mobile
Martins
Ladybug Camp
Pine Mountain Camp
Fillmore
Santa Paula
Ojai
Pine Corral
Tunnel Ranch
Junction Camp
Skunk Campground
Martinez Place
Paradise Campground
Gifford Ranch
Garcin
La Panza
Acebedo
Reef Station
Houser Camp
Anglola
El Rico Ranch
Hacienda Ranch
Devils Den
Blackwells Corner
Superior Gun Club
Cameros Pumping Station
Milo
Halwee
Talus
Lower Campground
Harris Mill
Wofford Heights
Los Alamos
Ballard
Solvang
Cachuma Village
Four-H Camp
Las Cruces
Lento
Santa Barbara
100 Miles
50
0
50



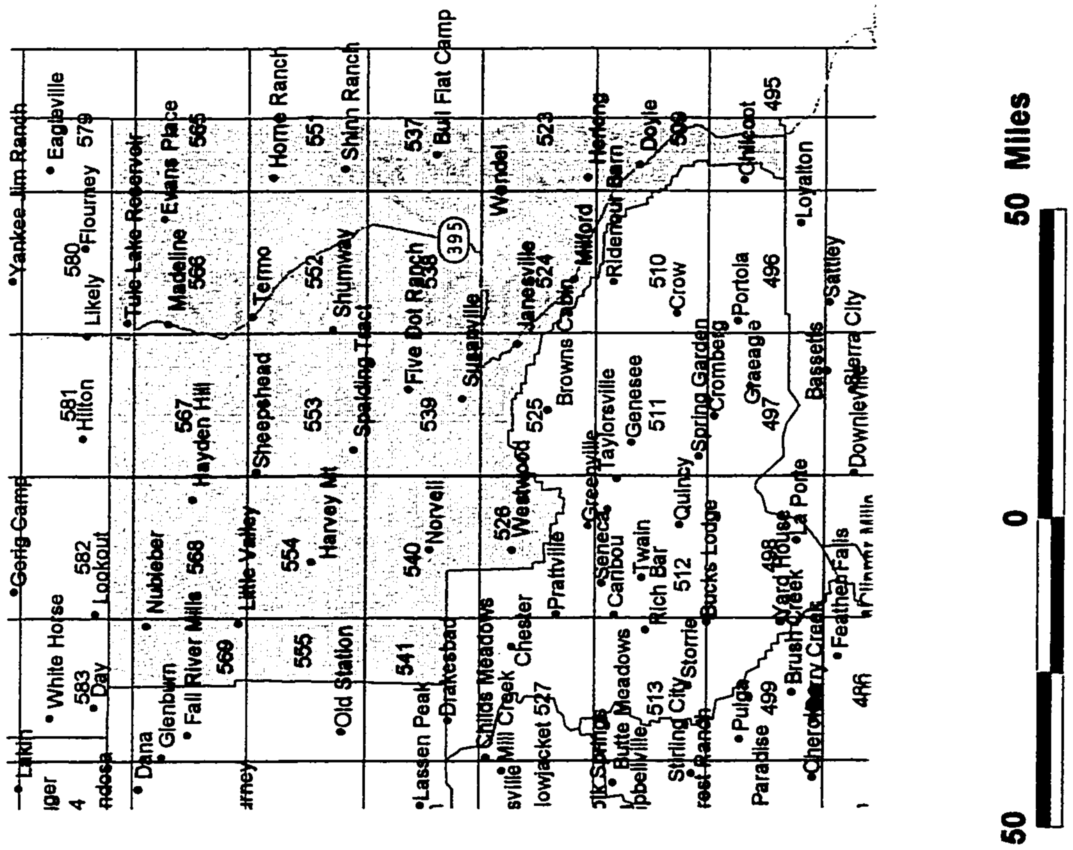
Orange Cove
Reedley
Dinuba
292
Parlier
Fowler
Selma
Kingsburg
Traver
Ivanh
Visalia
Goshen
Tulare
273
Octol
Waukena
Corcoran
Pixley
Angiola
255
Earlimart
Alpaugh
Delano
McFarl
234
Superior Gun Club
Hacienda Ranch
El Rico Ranch
Houser Camp
West Camp
235
Blackwells Corner
Hanford
Guernsey
Laton
Lemoore
274
Stratford
Middle Substation
256
Raisin City
Caruthers
293
Riverdale
Rossi
Vanguard
Kettleman City
Reef Station
Murray
5
Devils Den
236
Burrel
294
Helm
San Joaquin
Tranquillity
Westside
Califlax
Huron
275
Avenal
257
Annette
Avenedo
Cholame
Turk
Coalinga
276
Parkfield
258
Shandon
Whitley Gardens
237
Levis
Panoche Junction
295
Santa Rita Peak
Joaquin Mill
dria
leton
in Miguel
N
E
S
W
0
30
60 Miles

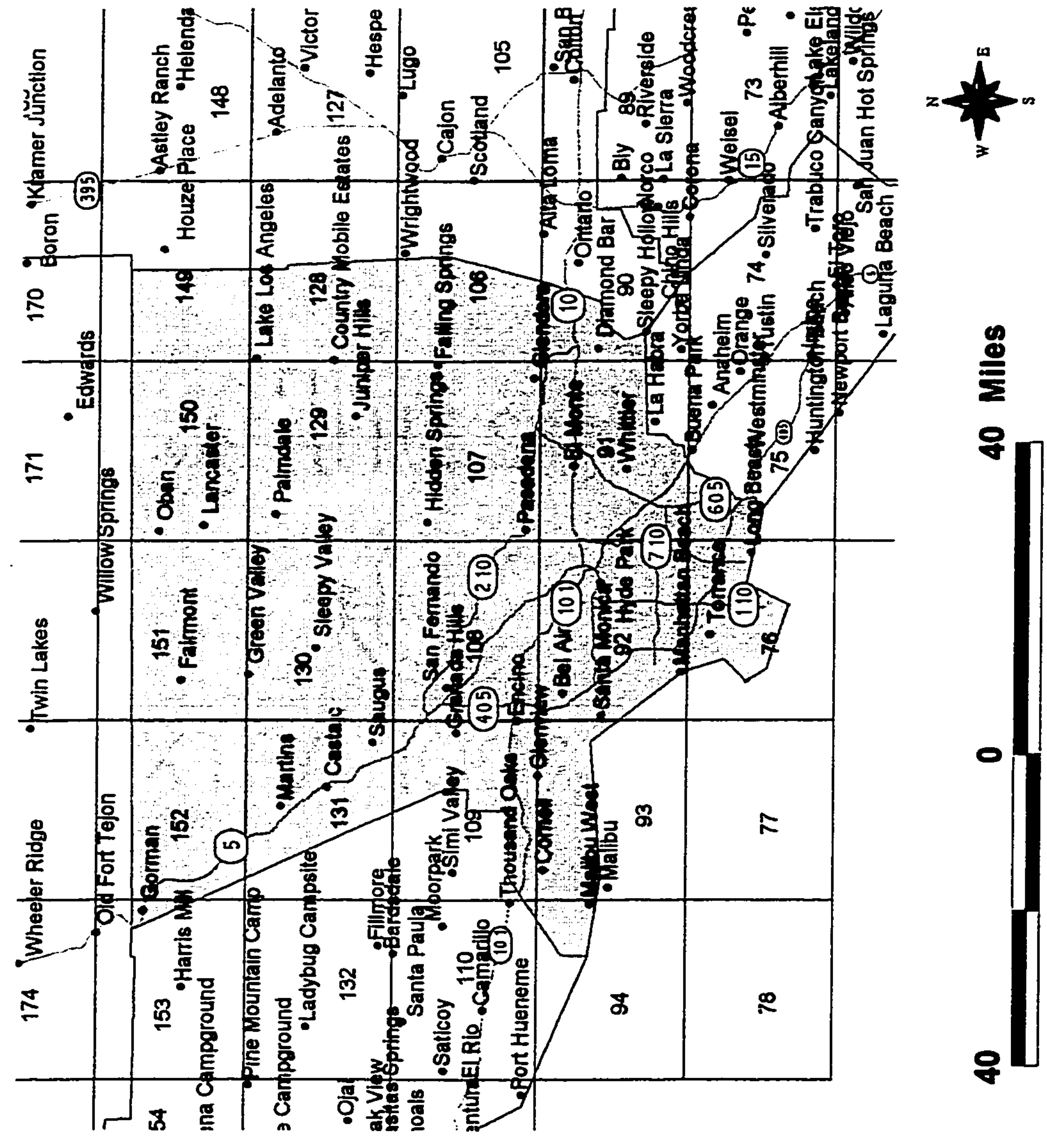
Lake Co



Alder Springs
Elk Creek
Fruto
Artois
Willows
Dogtown
Butler Camp
Windy Point Trailhead
Norman
Delevan
Stonyford
Fouts Springs
Lodoga
Sites
Maxwell
Delphos
Williams
Leesville
Pole Garden
Bartlett Springs
Bartlett Springs
Wilbur Springs
Clearlake Oaks
Lower Lake
Rumsey
Guinda
Knoxville
Brooks
Adams
Cobb
Middletown
Aetna Springs
Walter Springs
Pope Valley
Healdsburg
Four Pines
Fuller Ranch
Rice Fork
Enterprise
Potter Valley
Cooper
Upper Lake
Nice
Lucerne
Lakeport
Kelseyville
Purdys Gardens
Hopland
Cloverdale
Las Lomas
Trospers Club
Hearst
Calpella
Ukiah
Yorkville
Farley
Longvale
Willits
Boonville
Little Penny
Sea Ranch
Stewarts Point
488
489
490
491
492
475
476
477
478
479
463
464
465
466
467
449
450
451
452
453
5
101
30
0
30
Miles
N
S
E
W

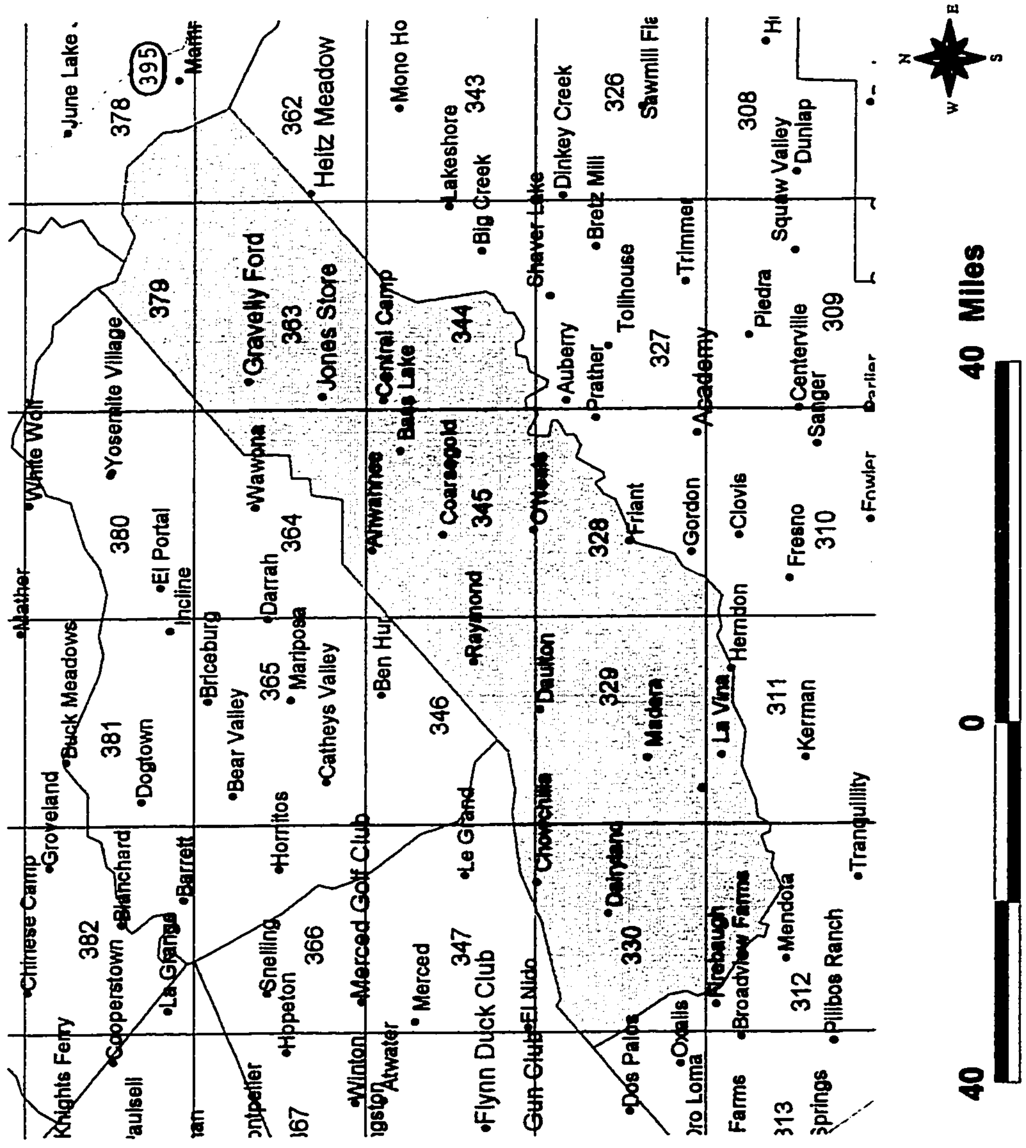
Lassen Co


Yankee Jim Ranch
Eagleville
579
580
Likely
Flournoy
Tule Lake Reservoir
Madeline
Evans Place
565
566
Termo
Home Ranch
552
Shumway
Shinn Ranch
537
538
Five Dot Ranch
Bull Flat Camp
395
Wendel
523
524
Janesville
Susanville
Milford
Doyle
510
Crow
Chilcoot
495
496
Portola
Loyalton
Sattley
Sierra City
581
Hilton
567
Hayden Hill
Sheepshead
553
Spalding Tract
539
525
Browns Cabin
Taylorsville
Genesee
511
Spring Garden
Cromberg
Graeagle
497
Bassetts
Downieville
Gerig Camp
582
Lookout
Nubieber
568
Little Valley
554
Harvey Mt
540
Norvell
526
Westwood
Greenville
Prattville
Seneca
Caribou
Twain
Rich Bar
512
Quincy
Bucks Lodge
498
Ward House
La Porte
Feather Falls
White Horse
583
Day
Glenburn
Fall River Mills
569
555
Old Station
541
Lassen Peak
Drakesbad
Childs Meadows
Mill Creek
Chester
527
Butte Meadows
513
Stirling City
Storrie
Pulga
499
Paradise
Brush Creek
Dana
N
E
S
W
50 Miles
0
50



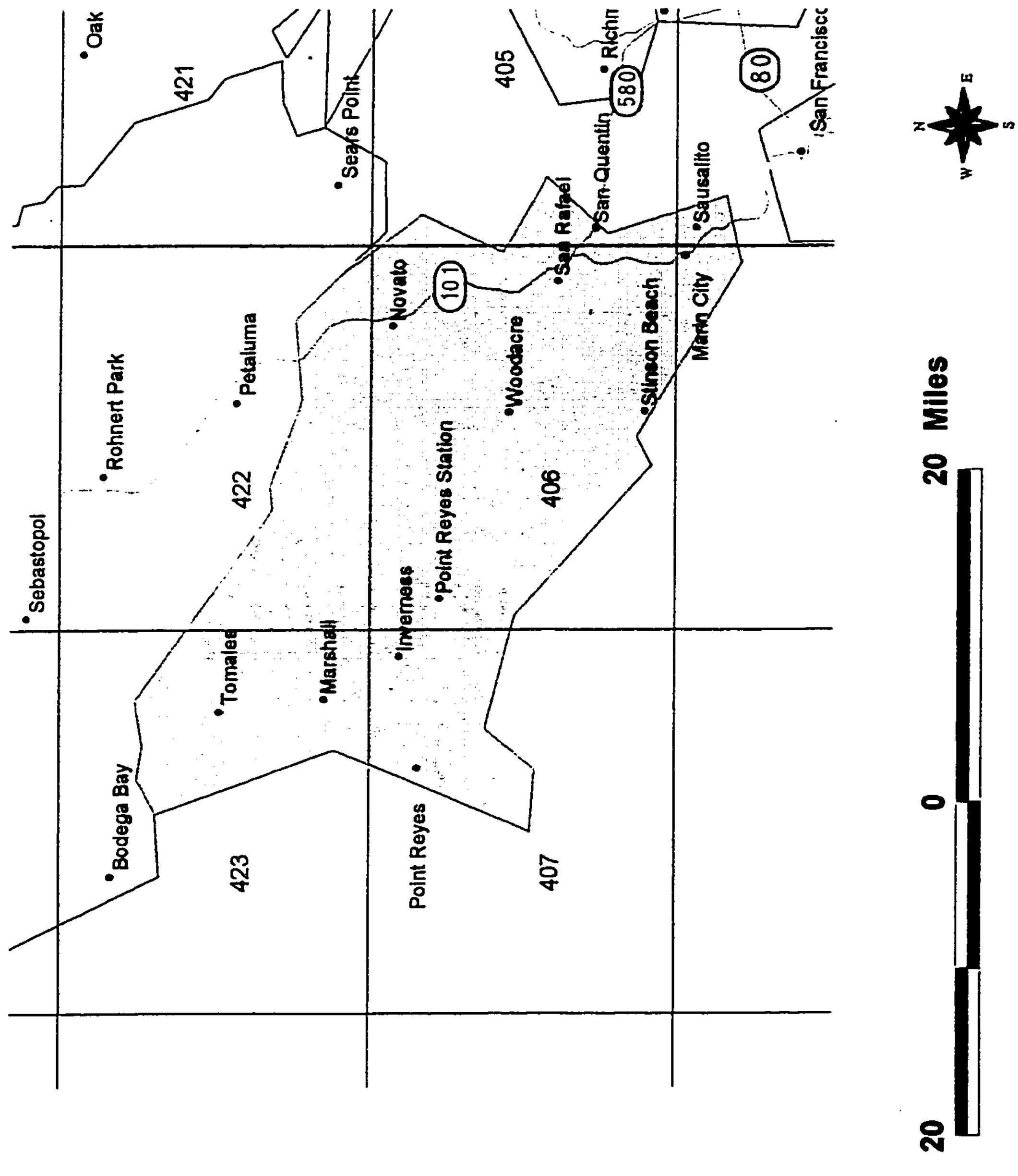
Kramer Junction
Boron
Edwards
Willow Springs
Twin Lakes
Wheeler Ridge
Old Fort Tejon
Gorman
Astley Ranch
Helendale
Houze Place
Oban
Lancaster
Fairmont
Lake Los Angeles
Palmdale
Green Valley
Adelanto
Victor
Country Mobile Estates
Juniper Hills
Sleepy Valley
Martins
Castaic
Pine Mountain Camp
Ladybug Campsite
Lugo
Wrightwood
Cajon
Scotland
Falling Springs
Hidden Springs
San Fernando
Granada Hills
Saugus
Simi Valley
Moorpark
Fillmore
Bardsdale
Santa Paula
Saticoy
Camarillo
El Rio
Port Hueneme
Thousand Oaks
Encino
Glendora
Alta Loma
Ontario
Diamond Bar
Pasadena
El Monte
Whittier
La Habra
Bel Air
Santa Monica
Hyde Park
Manhattan Beach
Torrance
Long Beach
Westminster
Anaheim
Orange
Tustin
Silverado
Huntington Beach
Newport Beach
El Toro
Laguna Beach
San Juan Hot Springs
Trabuco Canyon
Alberhill
Weisel
Corona
La Sierra
Riverside
Norco
Bly
Sleepy Hollow
Chino Hills
Yorba Linda
Buena Park
Malibu West
Malibu
Cornell
174
170
171
148
149
150
151
152
153
127
128
129
130
131
132
105
106
107
108
109
110
89
90
91
92
93
94
73
74
75
76
77
78
395
5
405
101
210
10
605
710
110
15
N
E
S
W
40
0
40 Miles

Madera Co

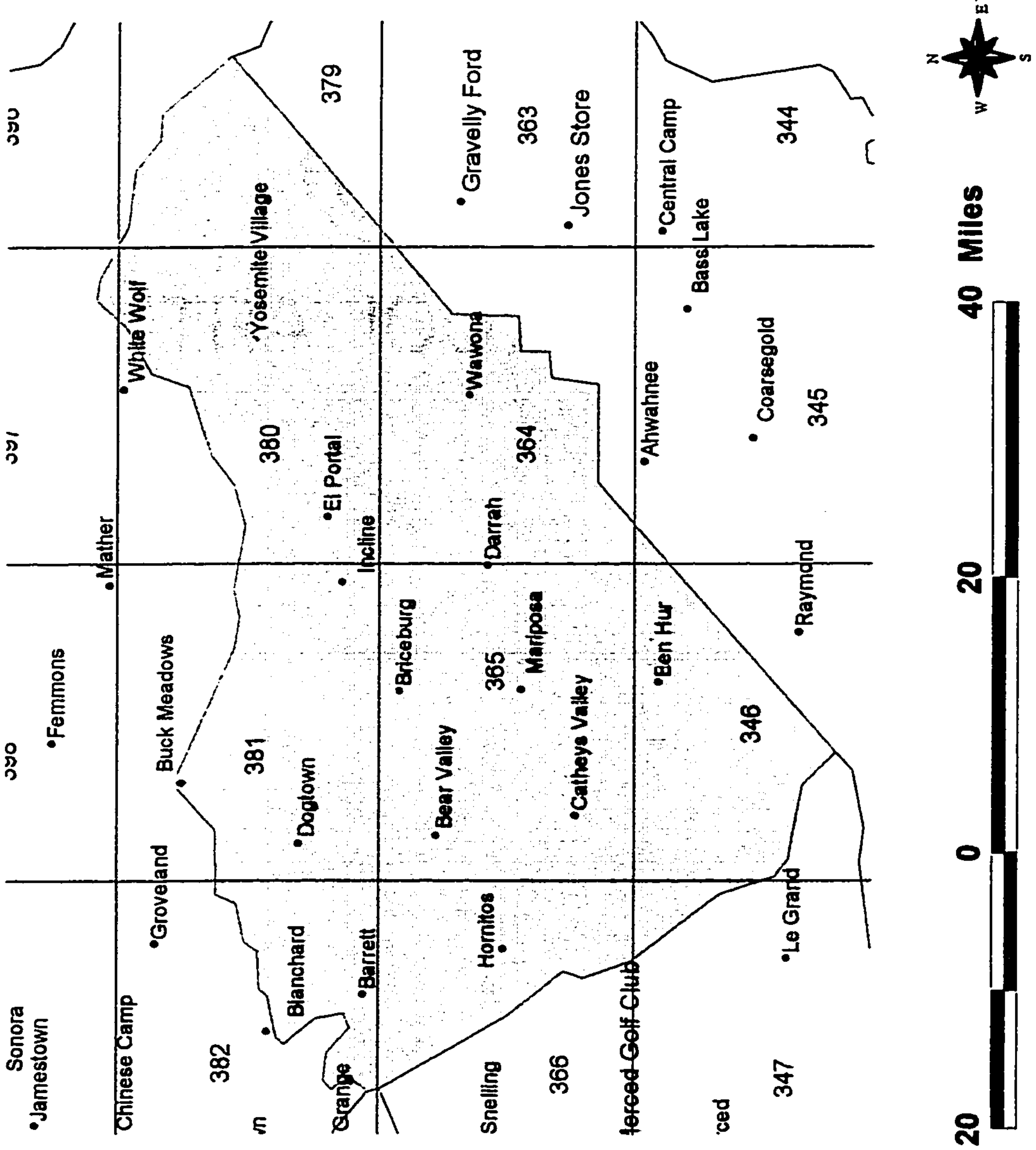


June Lake
378
395
362
Heitz Meadow
Mono Ho
Lakeshore
343
Big Creek
Shaver Lake
Dinkey Creek
Bretz Mill
326
Sawmill Fla
308
Squaw Valley
Dunlap
Trimmer
379
Gravelly Ford
363
Jones Store
Central Camp
Bass Lake
344
Auberry
Prather
Tollhouse
327
Academy
Piedra
Centerville
Sanger
309
Yosemite Village
White Wolf
380
El Portal
Incline
Wawona
Darrah
364
Ahwahnee
Coarsegold
345
O'Neals
328
Friant
Gordon
Clovis
Fresno
310
Fowler
Mather
Buck Meadows
381
Dogtown
Briceburg
Bear Valley
365
Mariposa
Catheys Valley
Ben Hur
346
Raymond
Daulton
329
Madera
La Vina
Herndon
311
Kerman
Groveland
Chinese Camp
382
Cooperstown
Blanchard
La Grange
Barrett
Hornitos
Snelling
Hopeton
366
Merced Golf Club
Merced
347
Le Grand
Flynn Duck Club
El Nido
Chowchilla
Dairyland
330
Mendota
Broadview Farms
312
Pilibos Ranch
Tranquillity
Knights Ferry
Winton
Atwater
Gun Club
Dos Palos
Oxalis
Firebaugh
40
0
40 Miles
N
E
S
W

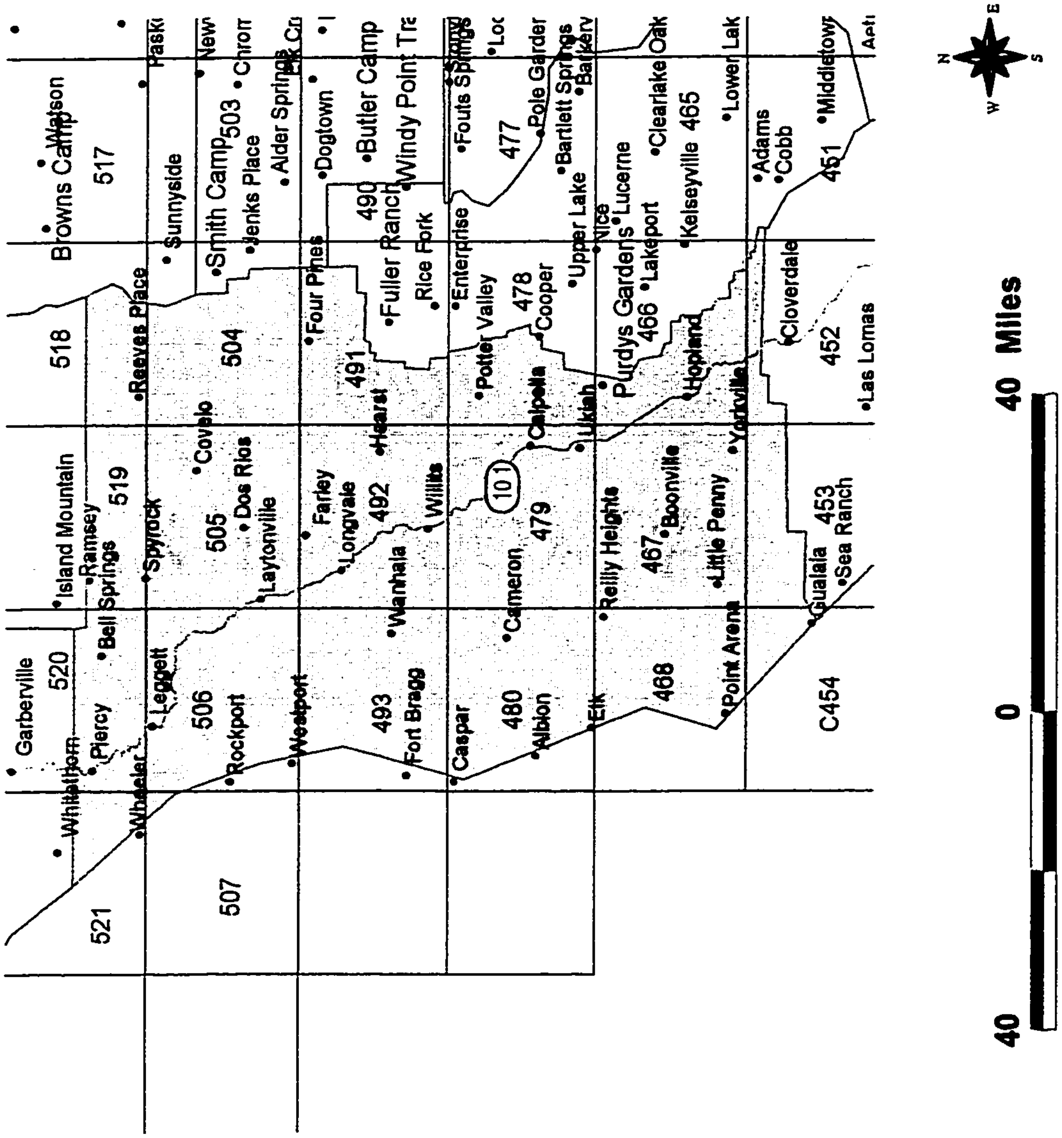
Marin Co


Oak
421
Sears Point
405
Richm
580
80
San Francisco
Sebastopol
Rohnert Park
Petaluma
422
Novato
101
Woodacre
San Rafael
San Quentin
Sausalito
Stinson Beach
Marin City
Point Reyes Station
406
Inverness
Tomales
Marshall
Bodega Bay
423
Point Reyes
407
N
E
S
W
20 Miles
0
20

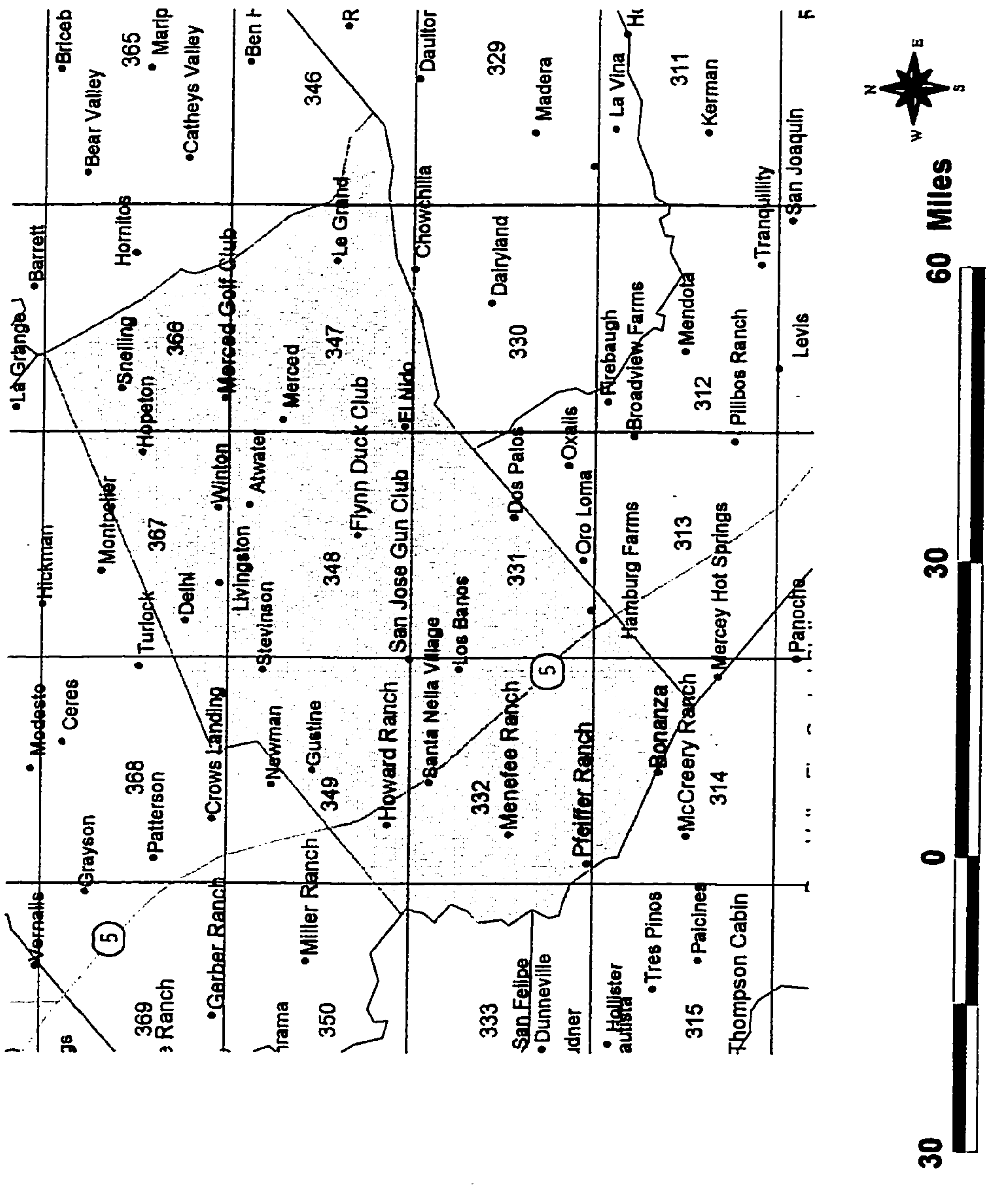
Mariposa Co


Sonora
Jamestown
Chinese Camp
Groveland
Femmons
Buck Meadows
Mather
White Wolf
Yosemite Village
382
381
380
379
Blanchard
Barrett
Grange
Dogtown
El Portal
Incline
Briceburg
Bear Valley
Hornitos
Snelling
366
365
364
363
Mariposa
Darrah
Wawona
Gravelly Ford
Jones Store
Catheys Valley
Merced Golf Club
Ben Hur
Ahwahnee
Central Camp
Bass Lake
Coarsegold
Raymond
Le Grand
347
346
345
344
20
0
20
40
Miles
N
E
S
W

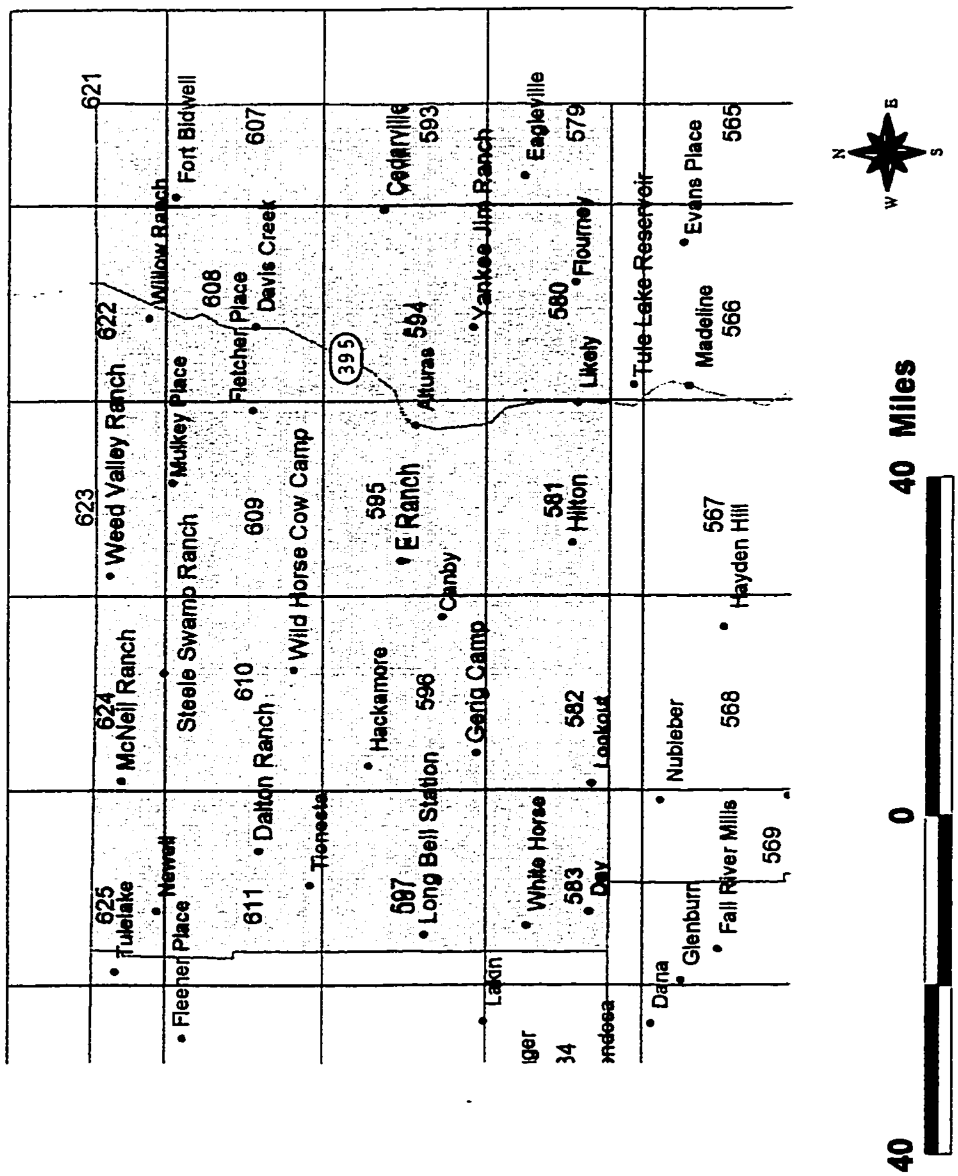
Mendocino Co



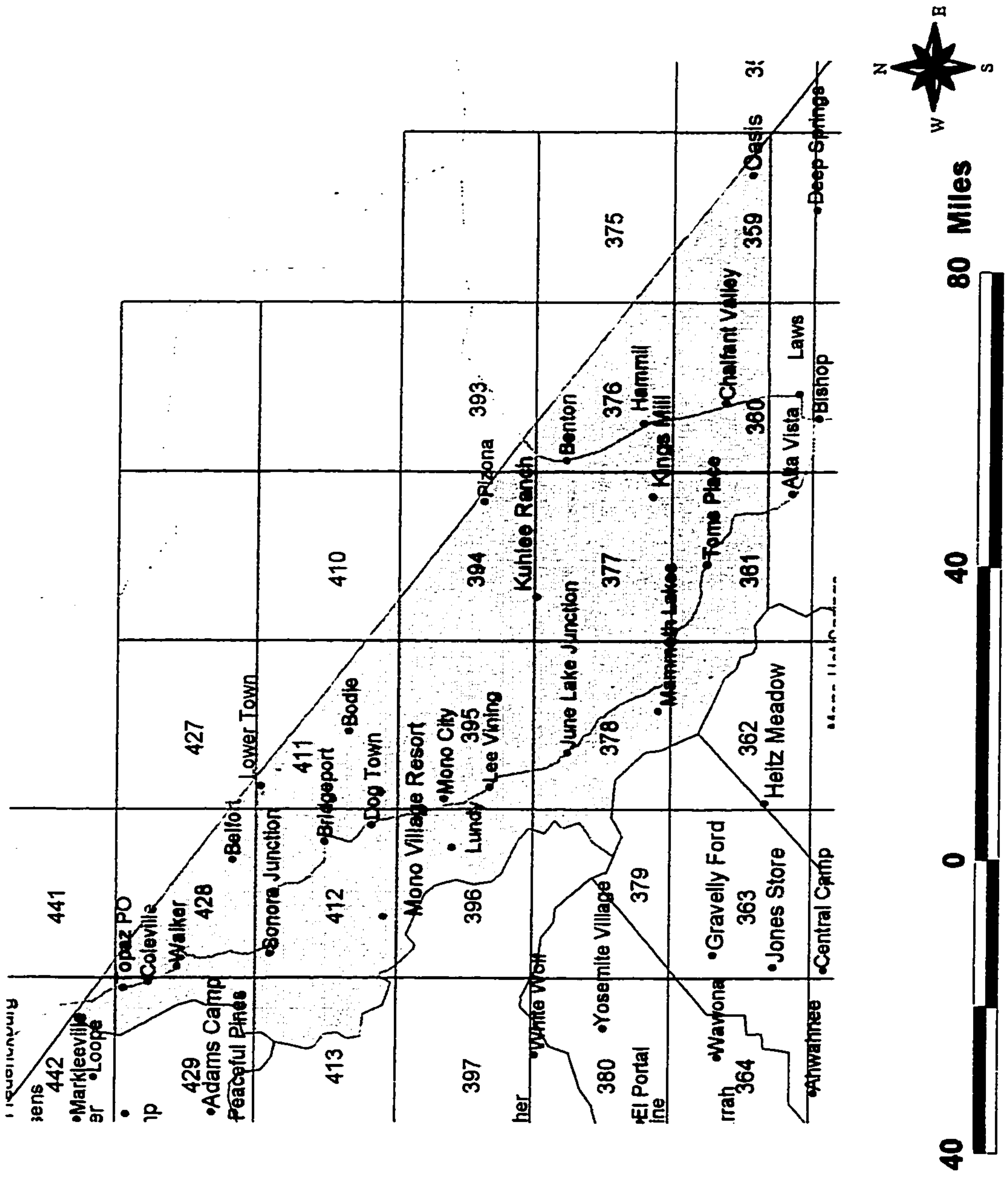
Merced Co



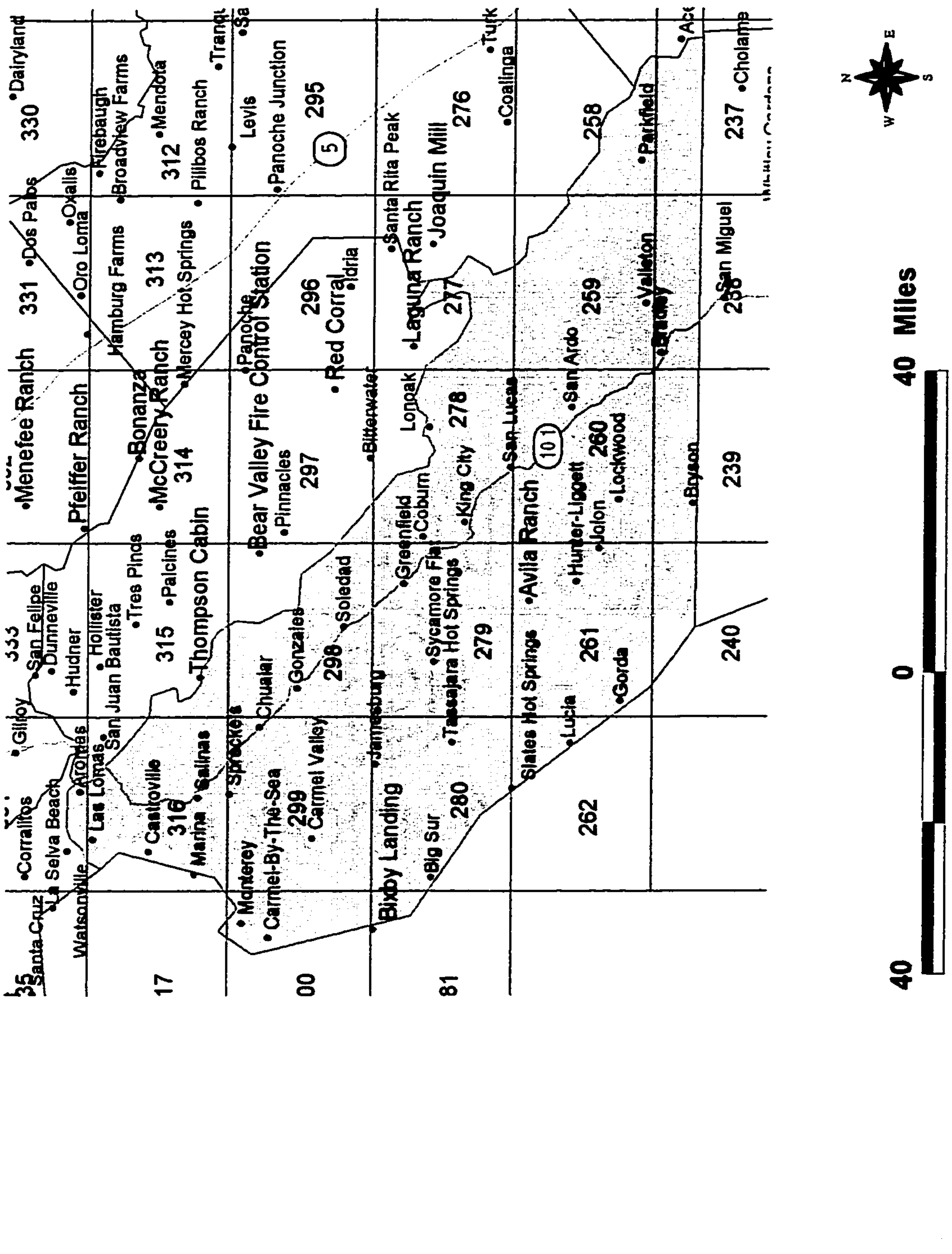
La Grange
Barrett
Hornitos
Snelling
Hopeton
366
Merced Golf Club
Merced
347
Le Grand
Chowchilla
Dairyland
330
El Nido
Flynn Duck Club
Atwater
Winton
Montpelier
Hickman
367
Turlock
Delhi
Livingston
Stevinson
348
San Jose Gun Club
Santa Nella Village
Los Banos
331
Dos Palos
Oxalis
Oro Loma
Firebaugh
Broadview Farms
Mendota
312
Pilibos Ranch
Hamburg Farms
313
Mercey Hot Springs
Panoche
Modesto
Ceres
368
Patterson
Grayson
Crows Landing
Newman
Gustine
349
Howard Ranch
332
Menefee Ranch
Pfeiffer Ranch
Bonanza
McCreery Ranch
314
Vernalis
369
Gerber Ranch
Miller Ranch
350
333
San Felipe
Dunneville
Hollister
Tres Pinos
Paicines
315
Thompson Cabin
Bear Valley
365
Catheys Valley
346
329
Madera
La Vina
311
Kerman
Tranquillity
San Joaquin
Levis
5
N
E
S
W
30
0
30
60 Miles



621
622
623
624
625
Fort Bidwell
607
Willow Ranch
608
Fletcher Place
Davis Creek
Weed Valley Ranch
Mulkey Place
Steele Swamp Ranch
609
Wild Horse Cow Camp
McNeil Ranch
610
Dalton Ranch
Tulelake
Newell
611
Tionesta
Fleener Place
Cedarville
593
Eagleville
579
Yankee Jim Ranch
Flournoy
580
594
Alturas
395
595
E Ranch
Canby
Hackamore
596
Gerig Camp
597
Long Bell Station
White Horse
583
Day
Likely
581
Hilton
582
Lookout
Tule Lake Reservoir
Evans Place
565
Madeline
566
567
Hayden Hill
568
Nubieber
569
Fall River Mills
Glenburn
Dana
Lakin
40
0
40 Miles


Topaz PO
Coleville
Walker
Adams Camp
Peaceful Pines
Markleeville
Loope
Belfort
Lower Town
Sonora Junction
Bridgeport
Bodie
Dog Town
Mono Village Resort
Mono City
Lundy
Lee Vining
June Lake Junction
Mammoth Lakes
Kuhlee Ranch
Pizona
Benton
Hammil
Kings Mill
Chalfant Valley
Toms Place
Alta Vista
Bishop
Laws
Oasis
Deep Springs
Heltz Meadow
Gravelly Ford
Jones Store
Central Camp
Yosemite Village
White Wolf
Wawona
Ahwahnee
El Portal
441
442
427
428
429
410
411
412
413
393
394
395
396
397
375
376
377
378
379
380
359
360
361
362
363
364
40
0
40
80 Miles
N
E
S
W

Monterey Co


Dairyland
330
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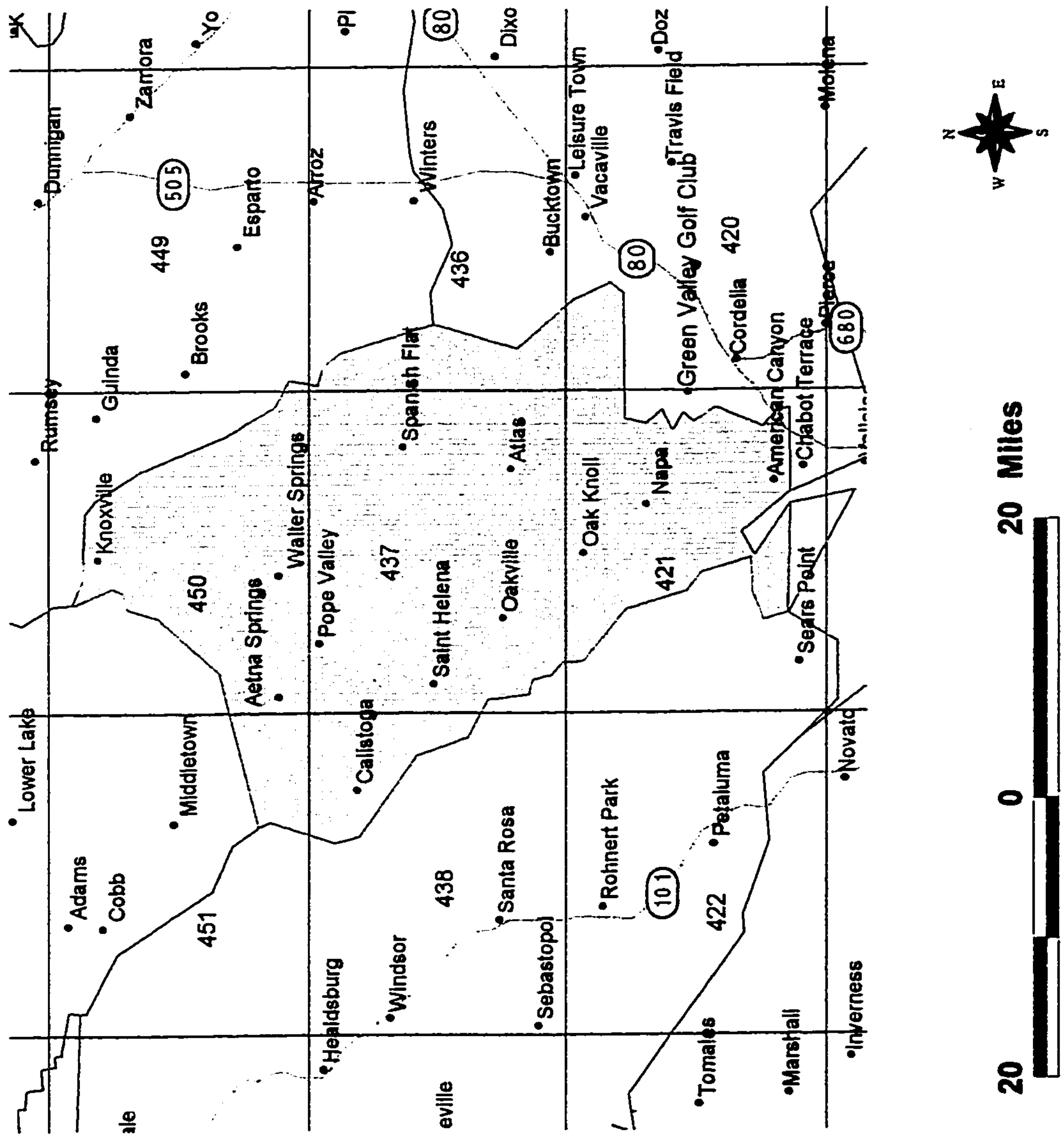
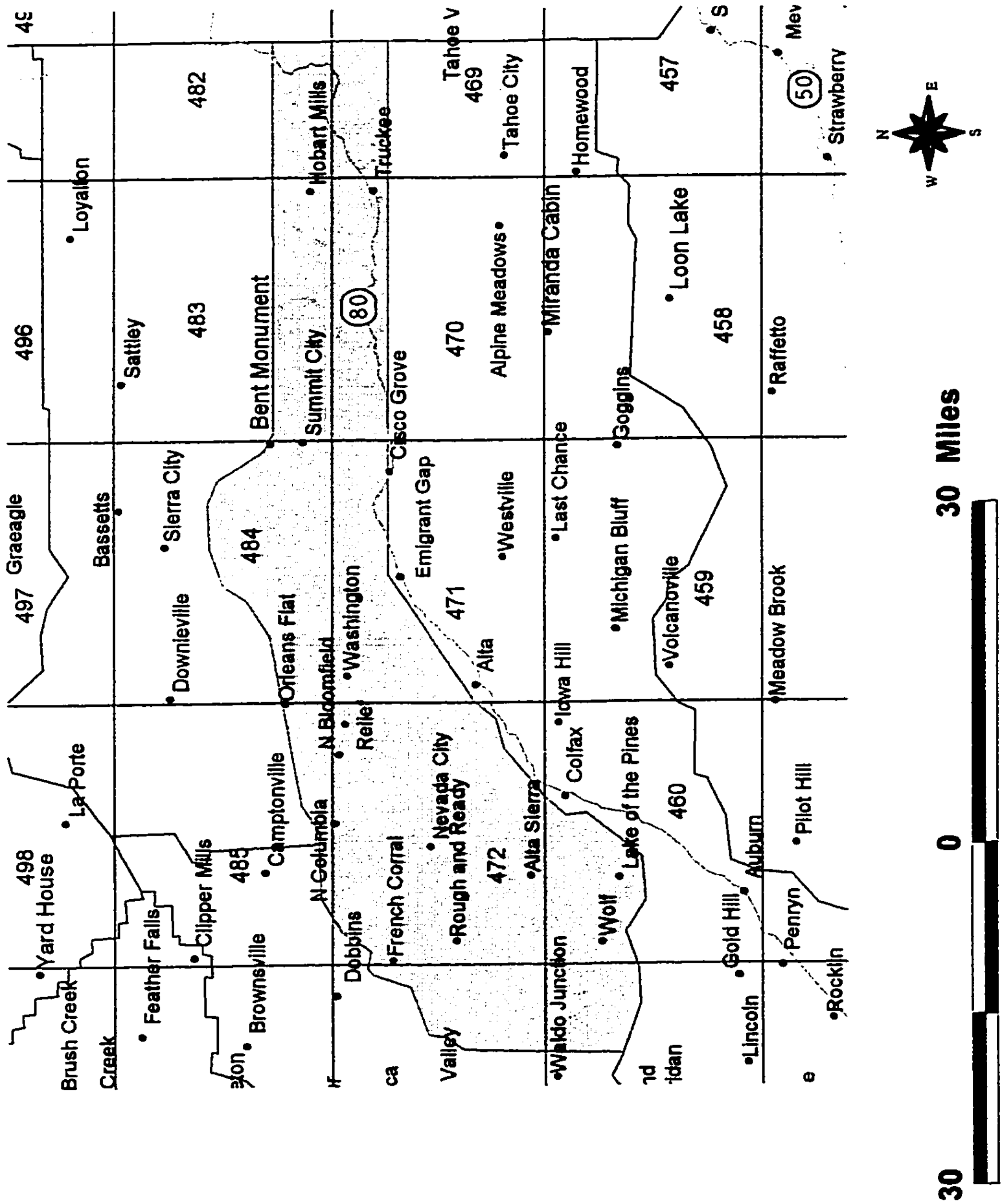
Dos Palos
Oxalis
Oro Loma
Firebaugh
Broadview Farms
Mendota
Hamburg Farms
312
313
Pillibos Ranch
Mercey Hot Springs
Levis
Panoche Junction
295
5
Menefee Ranch
Pfeiffer Ranch
Bonanza
McCreery Ranch
314
Panoche
Bear Valley Fire Control Station
296
Red Corral
Idria
Santa Rita Peak
Laguna Ranch
Joaquin Mill
276
Coalinga
277
258
Parkfield
259
Vallecitos
Bradley
San Miguel
237
Cholame
Pinnacles
297
Bitterwater
Lonoak
278
King City
Coburn
Greenfield
San Lucas
San Ardo
101
260
Lockwood
Hunter-Liggett
Jolon
Avila Ranch
239
Bryson
San Felipe
Dunneville
Hudner
Hollister
San Juan Bautista
Tres Pinos
Paicines
315
Thompson Cabin
Gonzales
Soledad
298
Sycamore Flat
Tassajara Hot Springs
279
Slates Hot Springs
261
Gorda
240
Gilroy
Aromas
Las Lomas
San Juan
Chualar
Spreckels
Castroville
Salinas
316
Marina
Monterey
Carmel-By-The-Sea
299
Carmel Valley
Jamesburg
Lucia
Corralitos
La Selva Beach
Watsonville
Santa Cruz
Bixby Landing
Big Sur
280
262
17
00
81
N
E
S
W
40
0
40
Miles

Napa Co



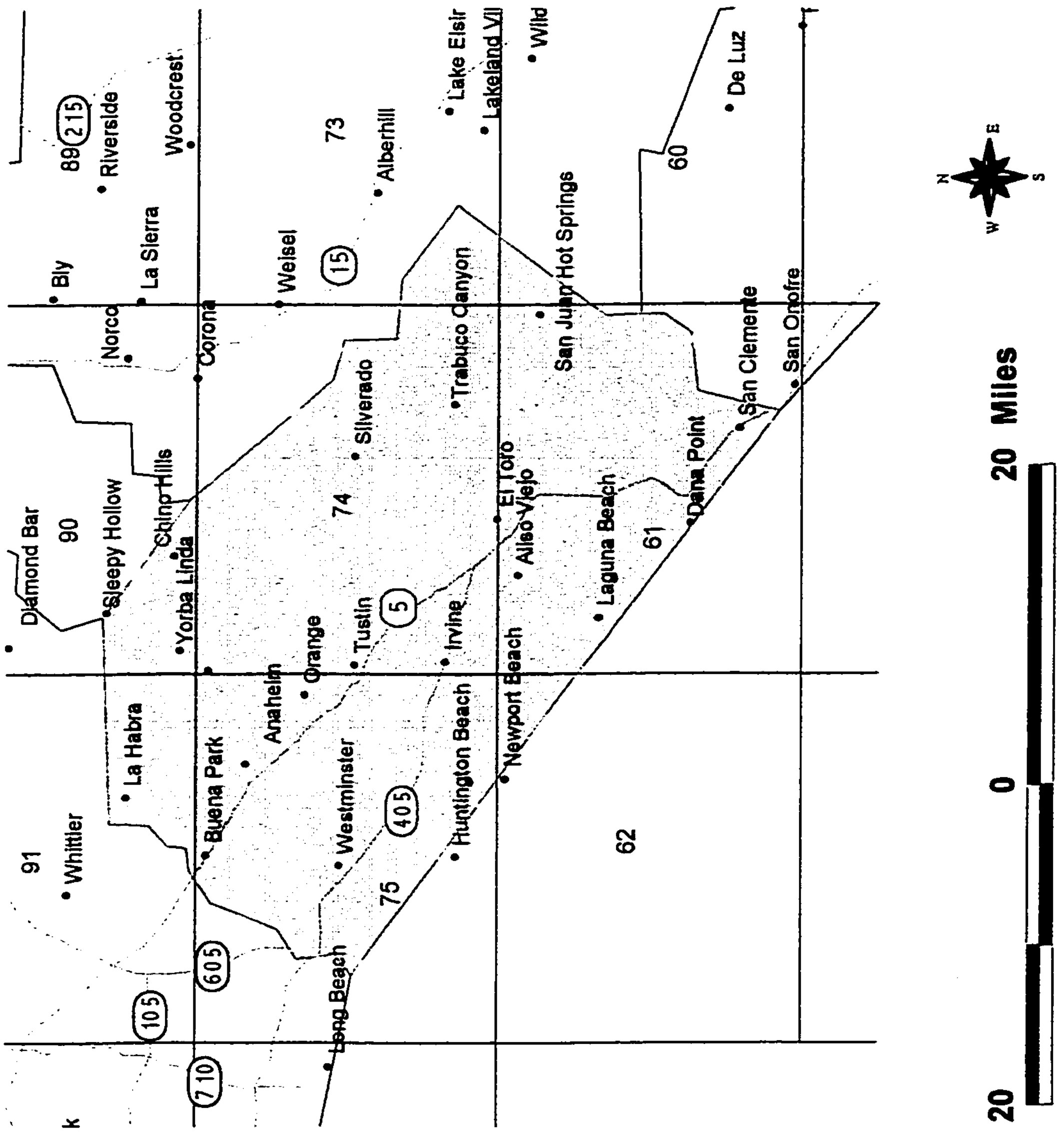
Dunnigan
Zamora
Rumsey
Guinda
Brooks
Esparto
449
505
Arroz
Winters
80
Dixo
Leisure Town
Vacaville
Bucktown
436
Travis Field
Doz
Green Valley Golf Club
420
Cordelia
American Canyon
Chabot Terrace
Molena
680
Knoxville
Walter Springs
Spanish Flat
Atlas
450
Pope Valley
437
Oak Knoll
Napa
Aetna Springs
Saint Helena
Oakville
421
Sears Point
Lower Lake
Middletown
Calistoga
Novato
Adams
Cobb
451
Healdsburg
Windsor
438
Santa Rosa
Sebastopol
Rohnert Park
101
Petaluma
422
Tomales
Marshall
Inverness
N
E
S
W
20
0
20 Miles

Nevada Co



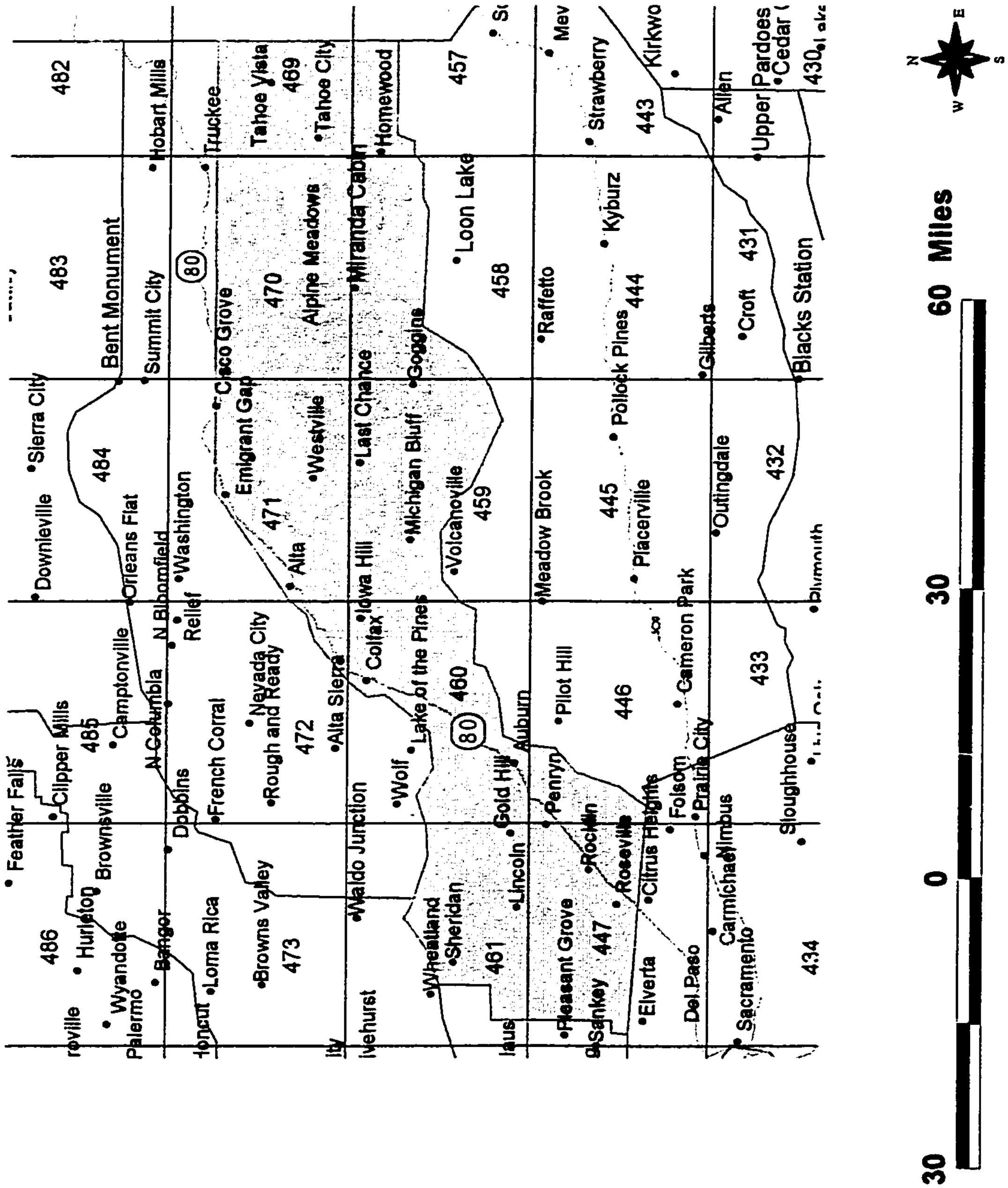
498
497
496
482
483
484
485
469
470
471
472
457
458
459
460
80
50
Yard House
Brush Creek
Creek
Feather Falls
La Porte
Clipper Mills
Brownsville
Camptonville
Graeagle
Bassetts
Sierra City
Downieville
Loyalton
Sattley
Bent Monument
Summit City
Hobart Mills
Truckee
Tahoe City
Homewood
Loon Lake
Alpine Meadows
Miranda Cabin
Cisco Grove
Emigrant Gap
Westville
Last Chance
Goggins
Michigan Bluff
Volcanoville
Orleans Flat
N Bloomfield
Washington
Relief
Alta
Iowa Hill
Colfax
N Columbia
Dobbins
French Corral
Rough and Ready
Nevada City
Alta Sierra
Lake of the Pines
Wolf
Waldo Junction
Valley
Gold Hill
Auburn
Lincoln
Penryn
Rocklin
Pilot Hill
Meadow Brook
Raffetto
Strawberry
N
E
S
W
30
0
30
Miles

Orange Co



Whittier
La Habra
Diamond Bar
Sleepy Hollow
Chino Hills
Yorba Linda
Buena Park
Anaheim
Orange
Tustin
Irvine
Westminster
Huntington Beach
Newport Beach
Long Beach
Corona
Norco
Bly
La Sierra
Riverside
Woodcrest
Weisel
Alberhill
Lake Elsir
Lakeland Vil
Wild
De Luz
Silverado
Trabuco Canyon
San Juan Hot Springs
El Toro
Aliso Viejo
Laguna Beach
Dana Point
San Clemente
San Onofre
91
90
89
215
73
74
75
15
5
405
605
105
710
60
61
62
N
E
S
W
20 Miles
0
20

Placer Co



482
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472
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457
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459
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461
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444
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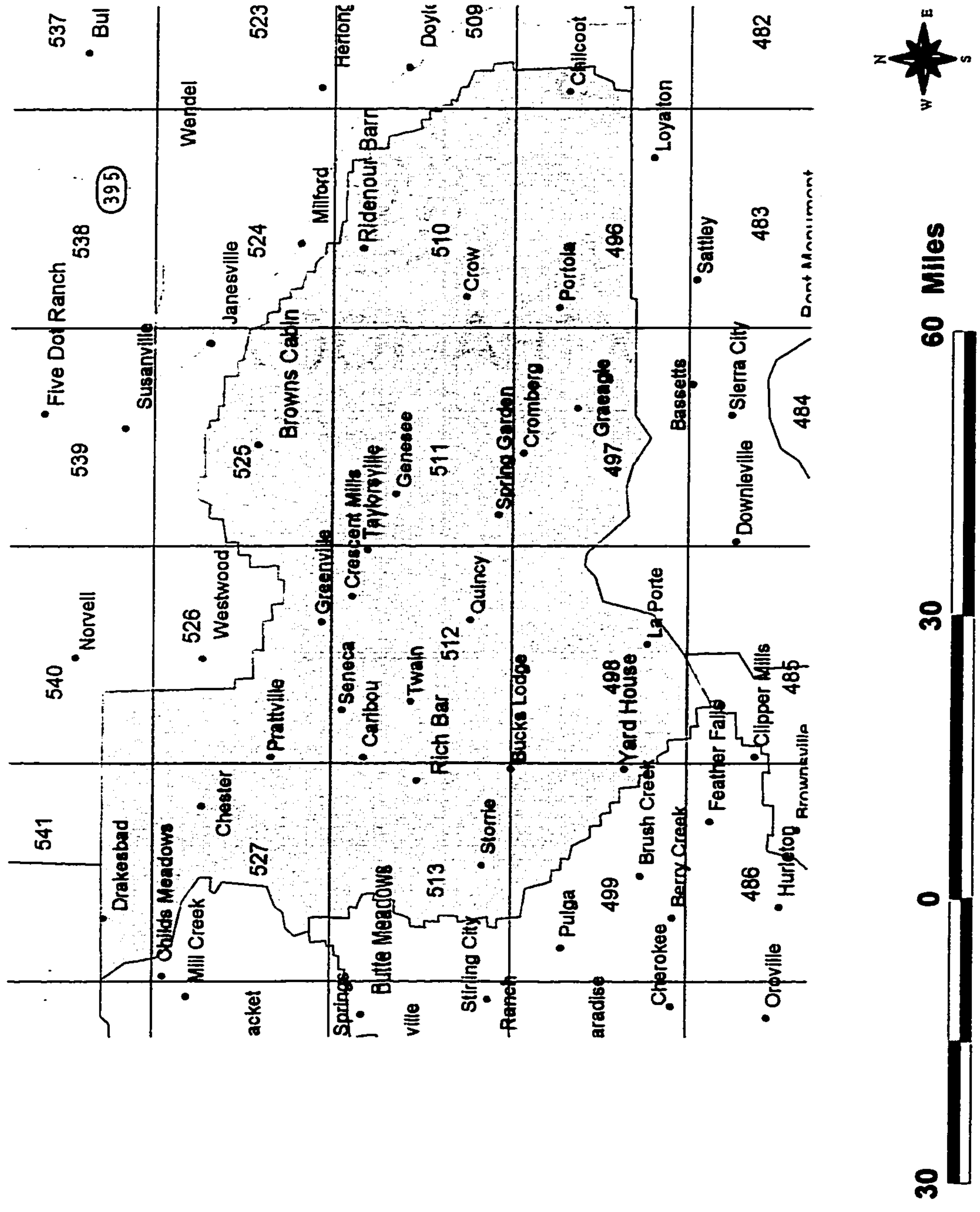
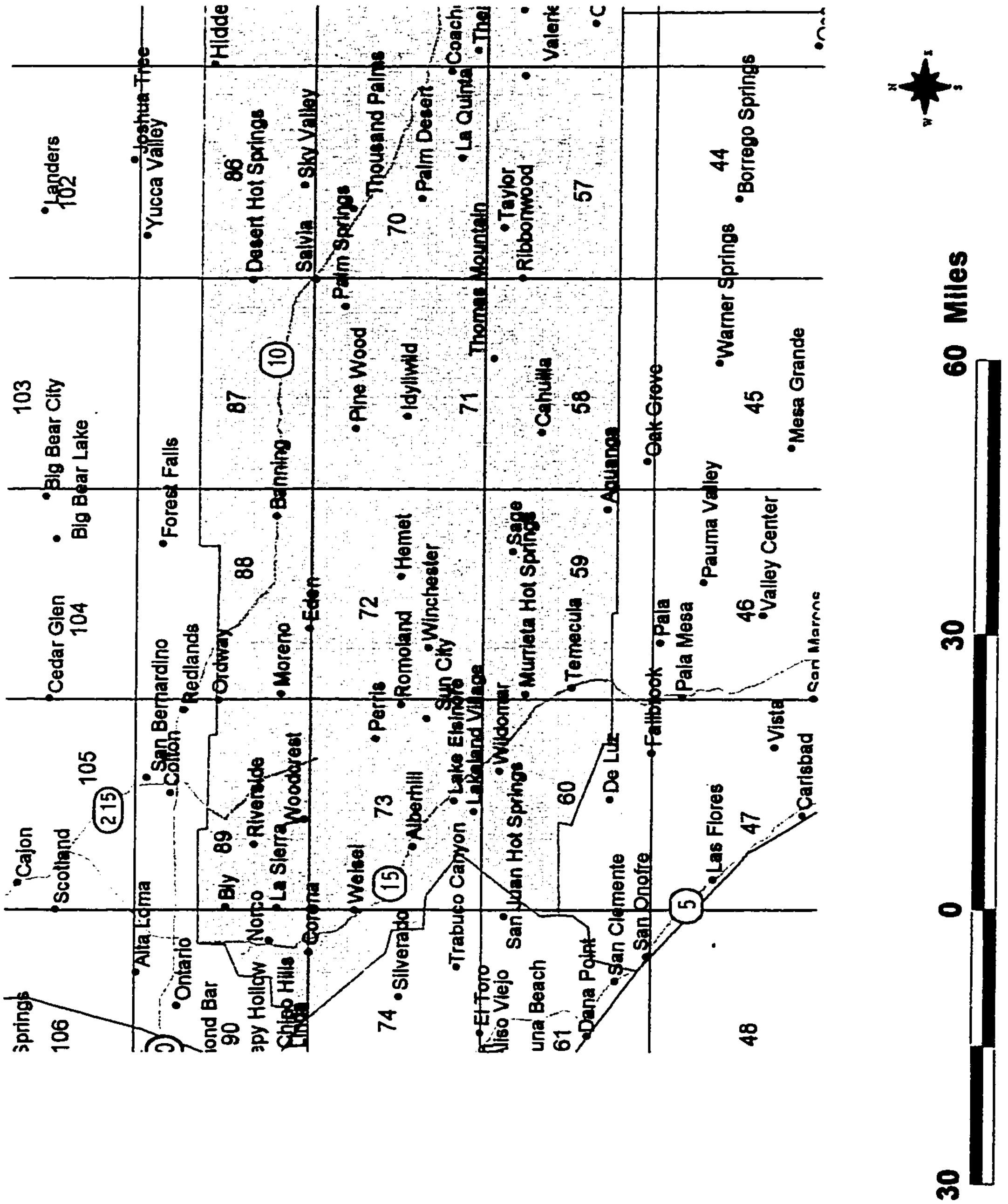
446
447
431
432
433
434
430
80
Feather Falls
Clipper Mills
Brownsville
Hurleton
Wyandotte
Palermo
Bangor
Loma Rica
Browns Valley
Dobbins
French Corral
N Columbia
Camptonville
Downieville
Sierra City
Bent Monument
Summit City
Hobart Mills
Truckee
Tahoe Vista
Tahoe City
Homewood
Miranda Cabin
Alpine Meadows
Cisco Grove
Emigrant Gap
Westville
Last Chance
Goggins
Michigan Bluff
Volcanoville
Iowa Hill
Alta
Washington
Orleans Flat
N Bloomfield
Relief
Nevada City
Rough and Ready
Alta Sierra
Colfax
Lake of the Pines
Wolf
Waldo Junction
Wheatland
Sheridan
Lincoln
Gold Hill
Auburn
Penryn
Rocklin
Roseville
Pleasant Grove
Sankey
Elverta
Citrus Heights
Folsom
Prairie City
Carmichael
Nimbus
Del Paso
Sacramento
Sloughhouse
Cameron Park
Pilot Hill
Meadow Brook
Placerville
Pollock Pines
Raffetto
Loon Lake
Kyburz
Strawberry
Kirkwood
Allen
Upper Pardoes
Cedar
Croft
Gilberts
Blacks Station
Outingdale
N
E
S
W
30
0
30
60 Miles

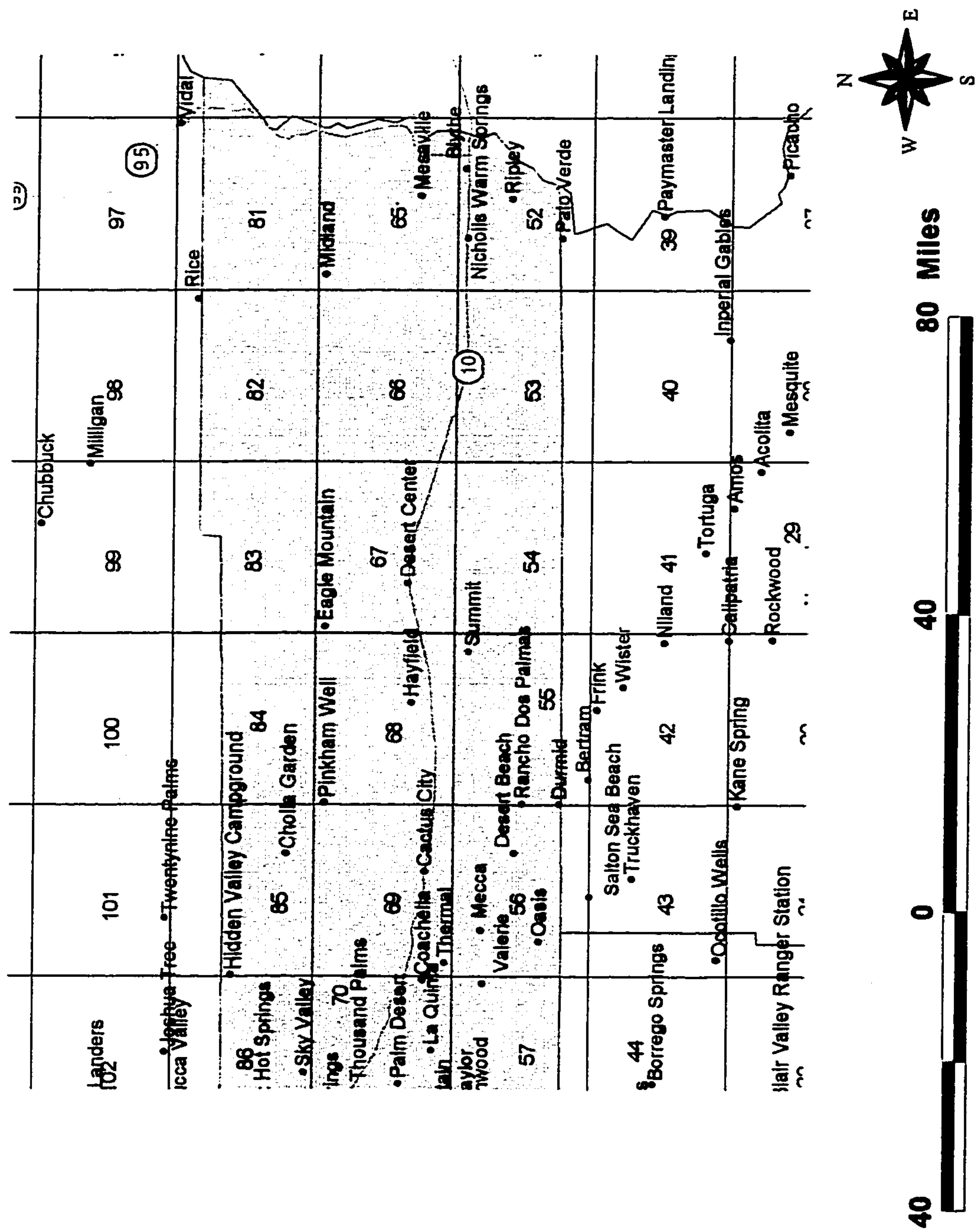
Plumas Co


537
Bul
523
Herlong
509
Chilcoot
482
Wendel
395
538
Five Dot Ranch
Janesville
524
Milford
Ridenour Barr
510
Crow
Portola
496
Loyalton
Sattley
483
Susanville
Browns Cabin
539
525
Crescent Mills
Taylorsville
Genesee
511
Spring Garden
Cromberg
Graeagle
497
Bassetts
Sierra City
484
Downieville
540
Norvell
526
Westwood
Greenville
Quincy
Seneca
Caribou
Twain
512
La Porte
498
Yard House
Clipper Mills
485
Prattville
Rich Bar
Bucks Lodge
Feather Falls
541
Drakesbad
Childs Meadows
Chester
527
Mill Creek
Butte Meadows
513
Stirling City
Storrie
Pulga
499
Brush Creek
Berry Creek
Cherokee
486
Hurleton
Oroville
N
E
S
W
30
0
30
60
Miles

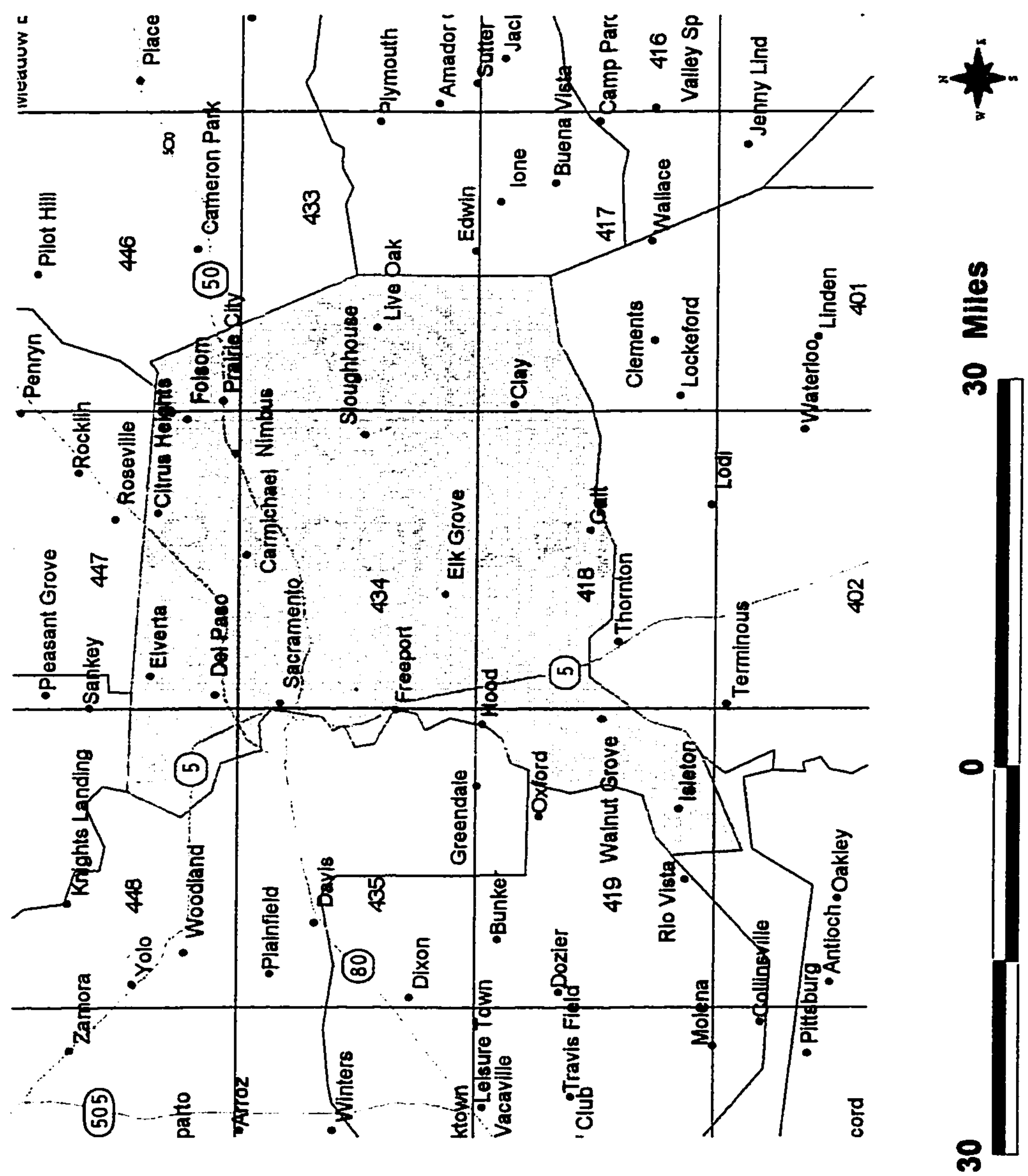
Riverside Co West



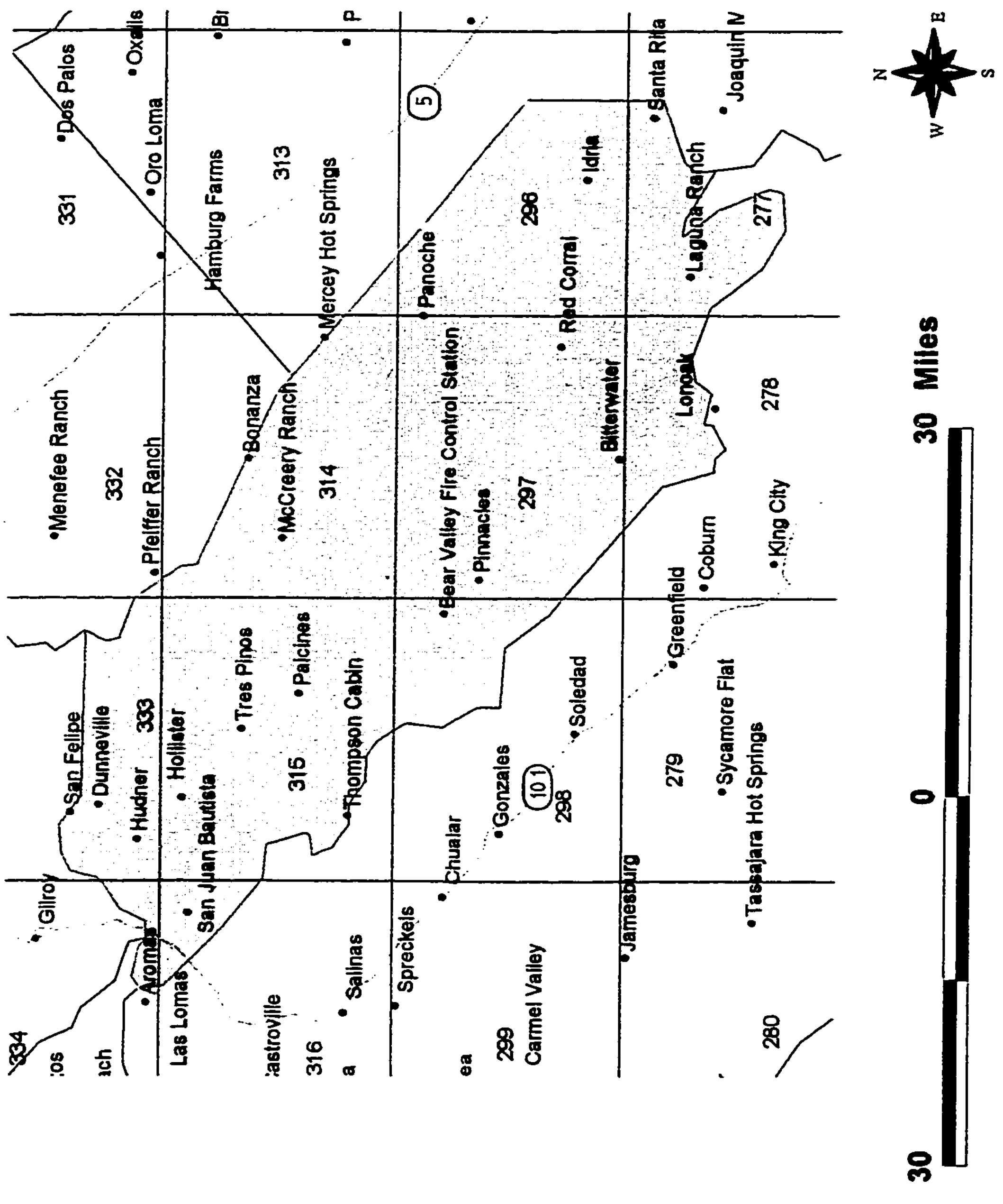
Riverside Co East



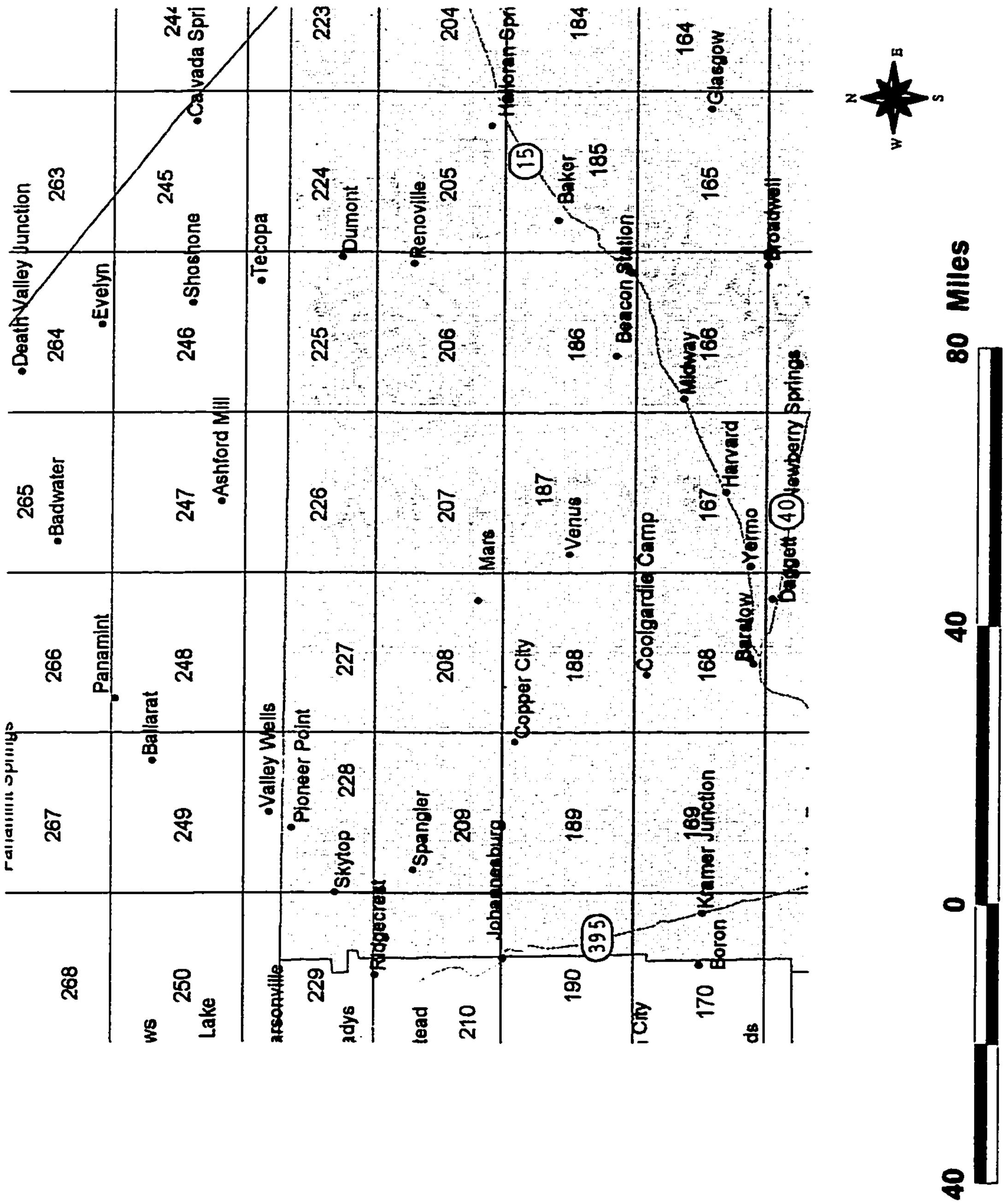
Sacramento Co



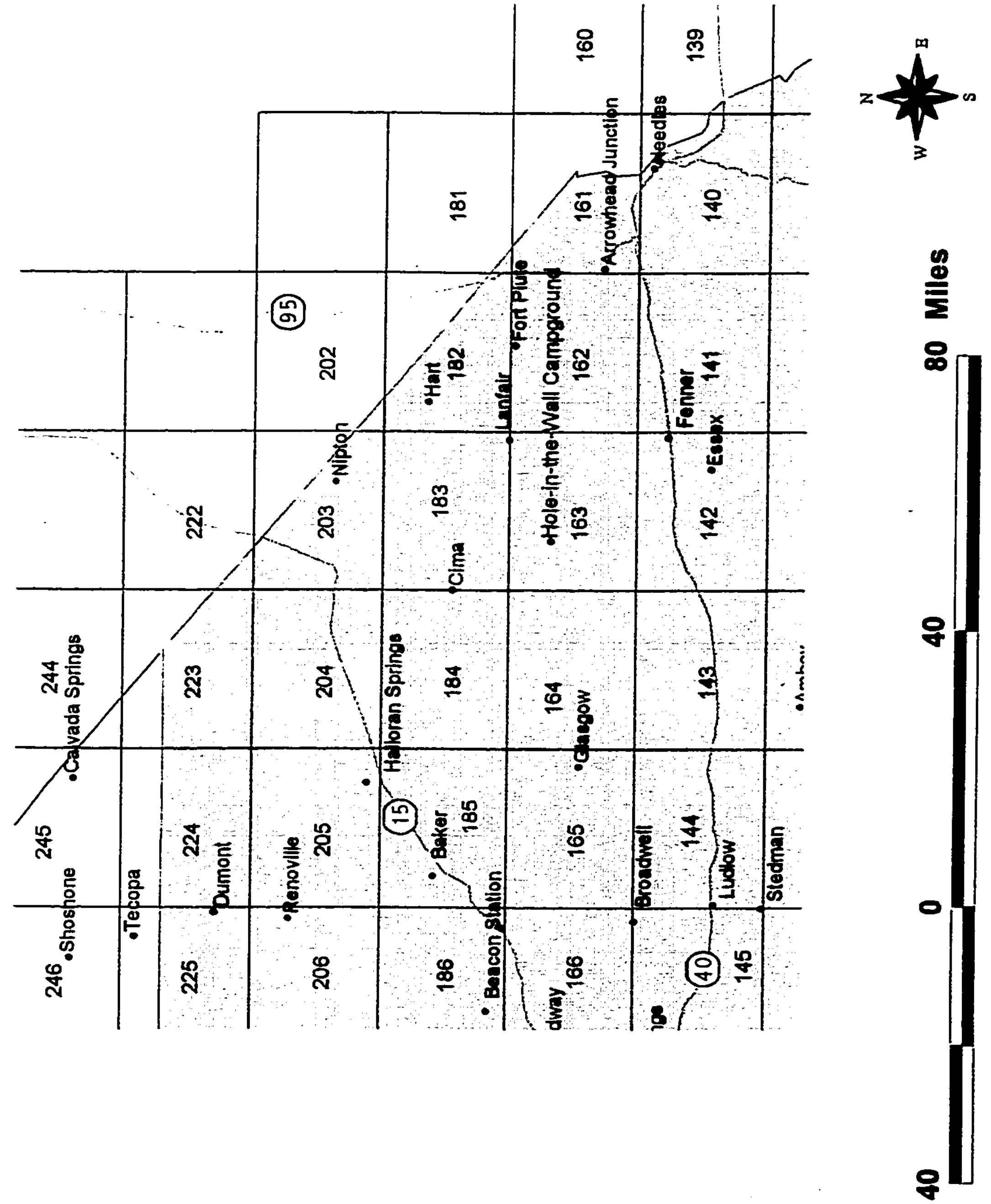
San Benito Co

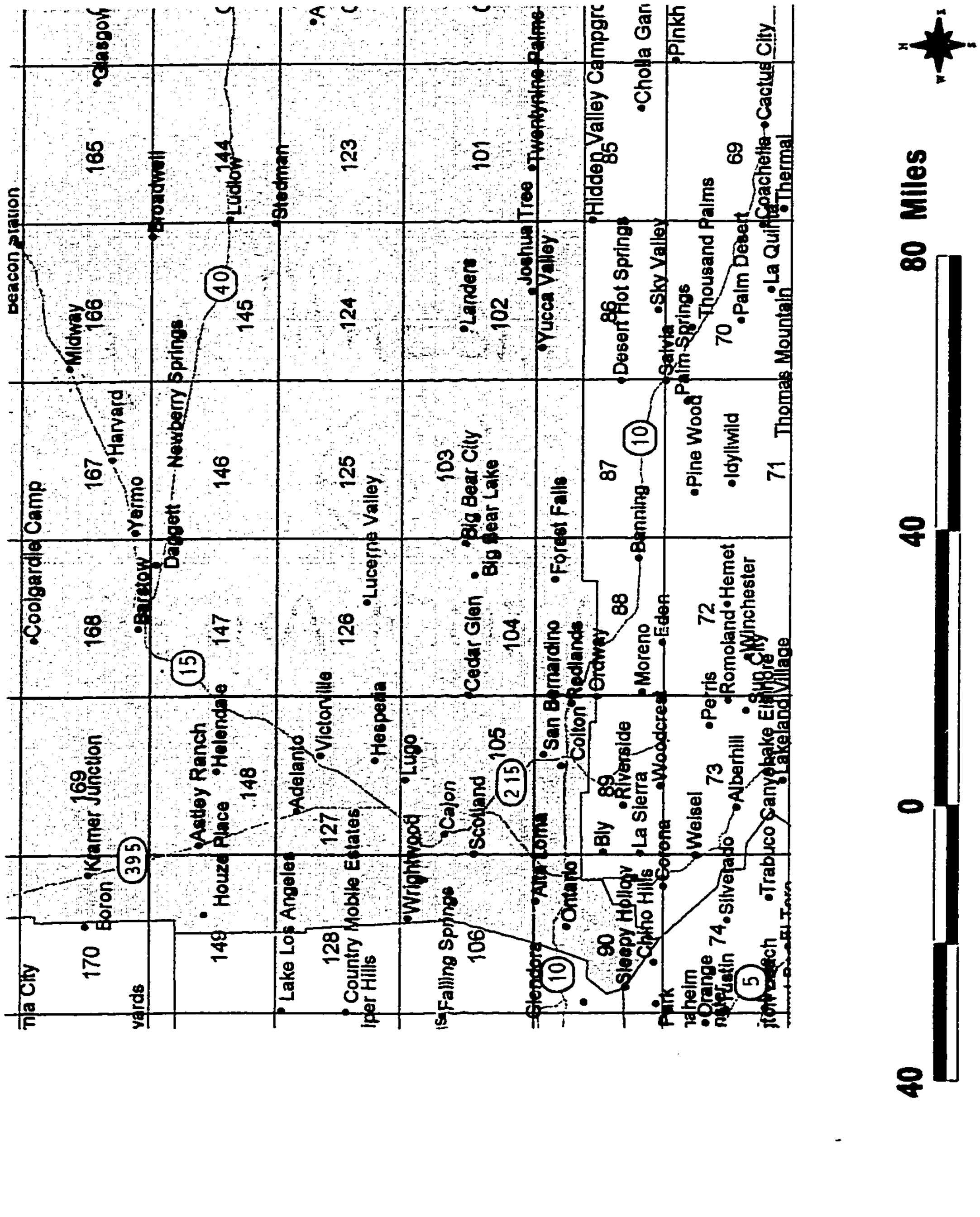


San Bernardino Co Northwest



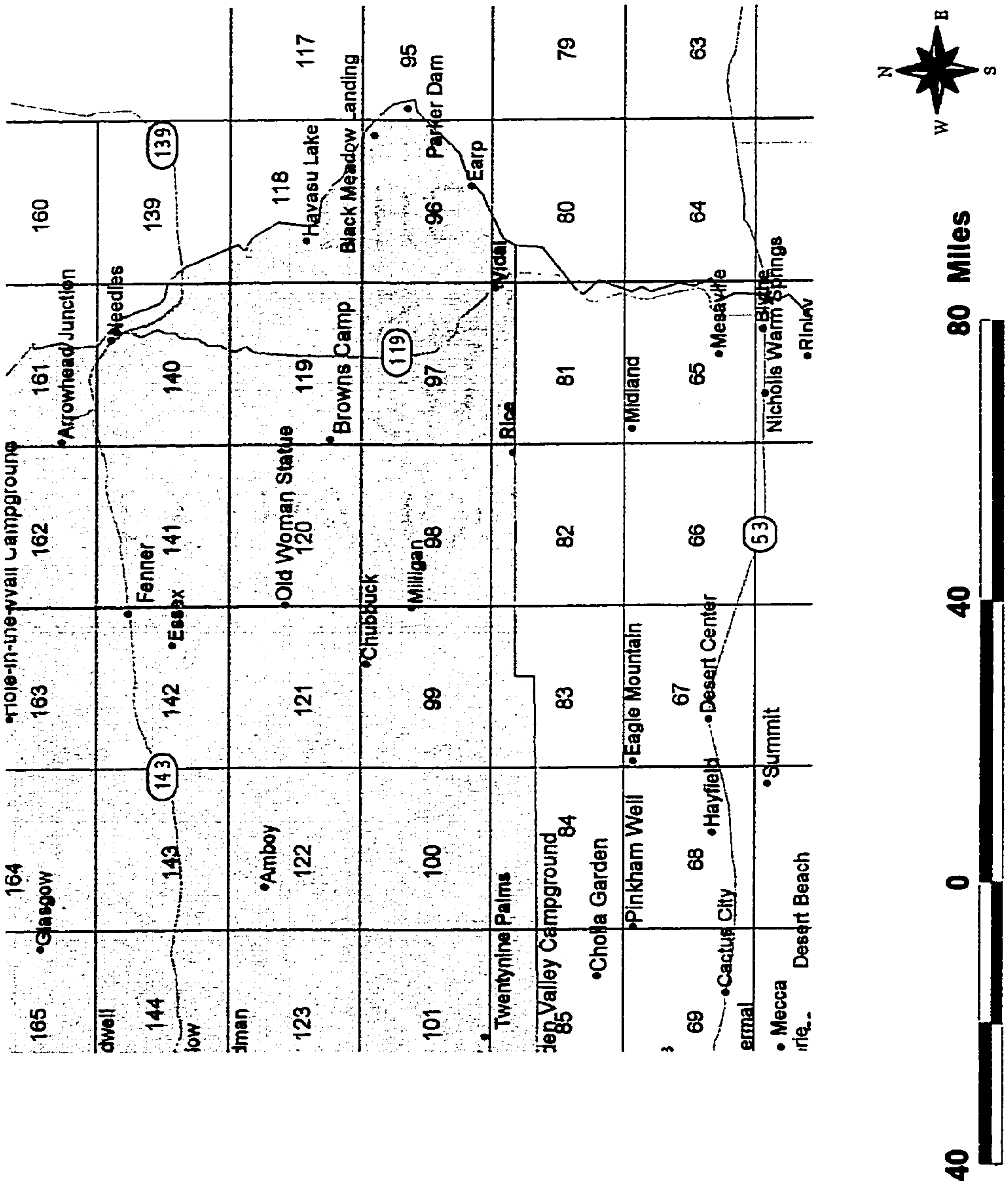
San Bernardino Co Northeast



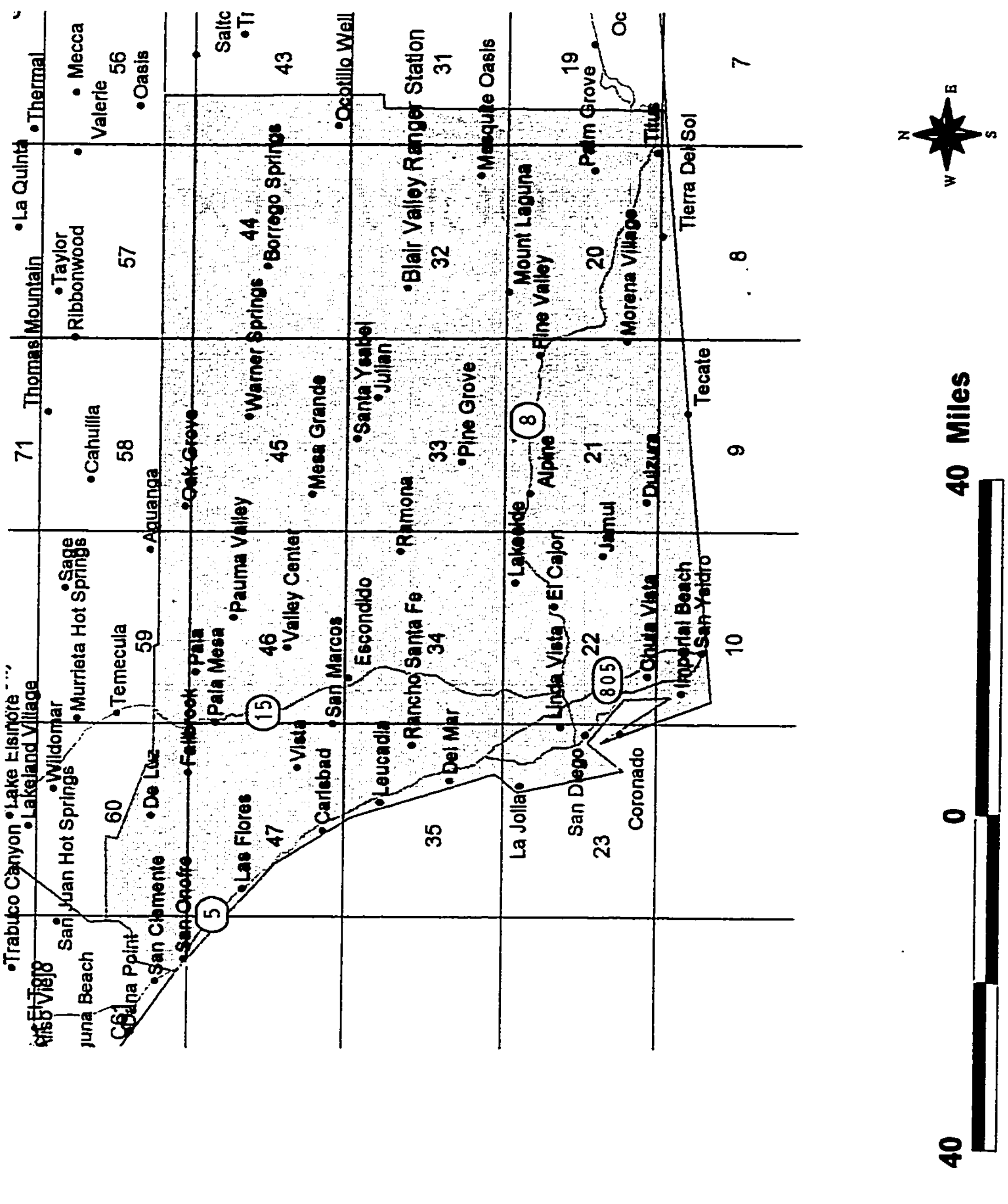


Beacon Station
Coolgardie Camp
Kramer Junction
Boron
Glasgow
Midway
Harvard
Yermo
Barstow
Daggett
Newberry Springs
Broadwell
Ludlow
Stedman
Astley Ranch
Helendale
Houze Place
Lake Los Angeles
Adelanto
Victorville
Country Mobile Estates
Hesperia
Lucerne Valley
Landers
Joshua Tree
Yucca Valley
Twentynine Palms
Hidden Valley Campgro
Cholla Gar
Pinkh
Wrightwood
Lugo
Cajon
Scotland
Cedar Glen
Big Bear City
Big Bear Lake
Falling Springs
Glendora
Alta Loma
Ontario
San Bernardino
Colton
Redlands
Forest Falls
Ordway
Bly
Riverside
La Sierra
Moreno
Banning
Desert Hot Springs
Sky Valley
Palm Springs
Thousand Palms
Palm Desert
La Quinta
Coachella
Cactus City
Thermal
Sleepy Hollow
Chino Hills
Corona
Woodcrest
Eden
Pine Wood
Idyllwild
Thomas Mountain
Welsel
Perris
Romoland
Hemet
Winchester
Alberhill
Sun City
Lakeland Village
Trabuco Canyon
Silverado
Tustin
Orange
Park
170
169
168
167
166
165
149
148
147
146
145
144
128
127
126
125
124
123
106
105
104
103
102
101
90
89
88
87
86
85
74
73
72
71
70
69
395
15
40
215
10
5
0
40
80 Miles

San Bernardino Co Southeast

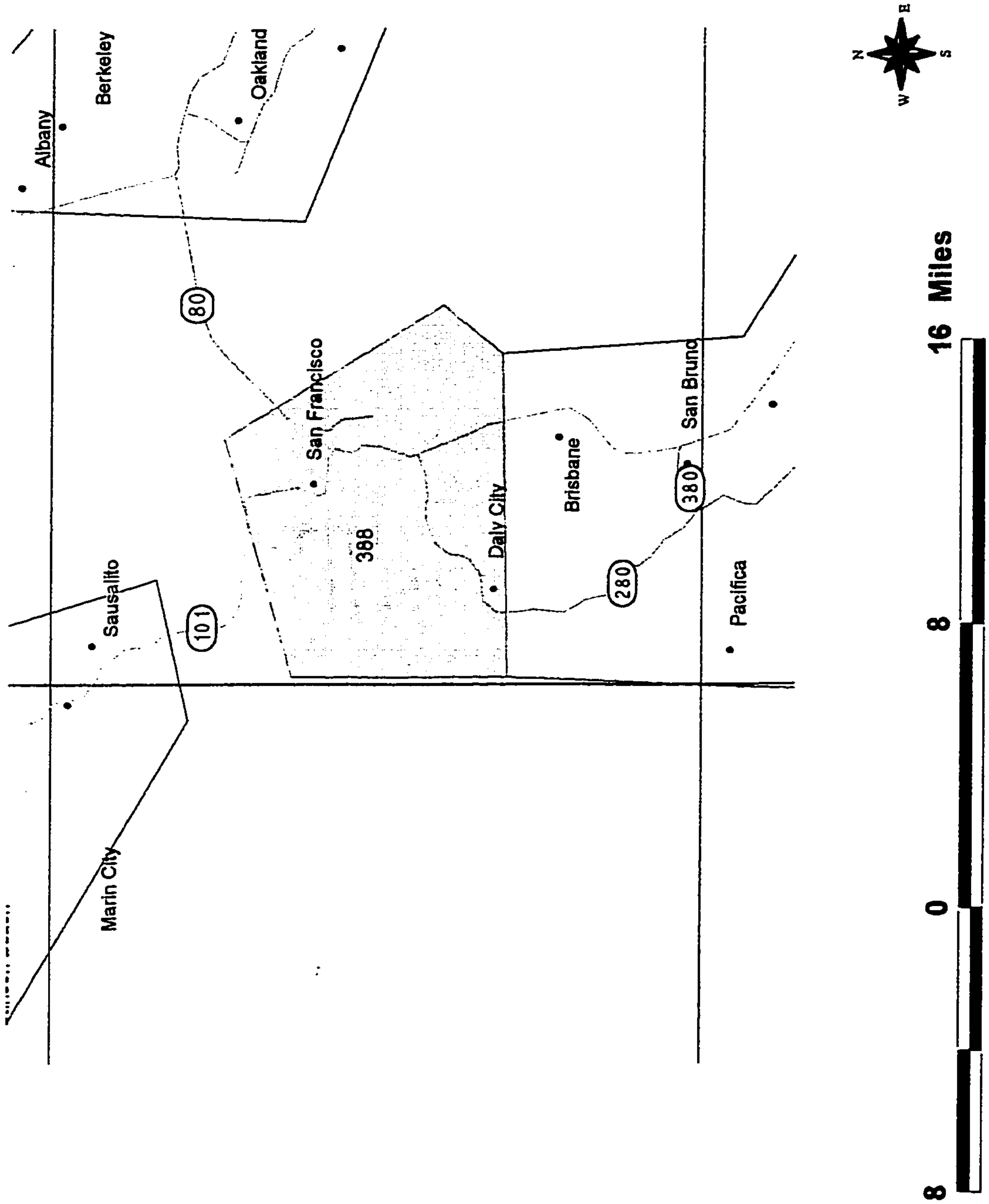


San Diego Co

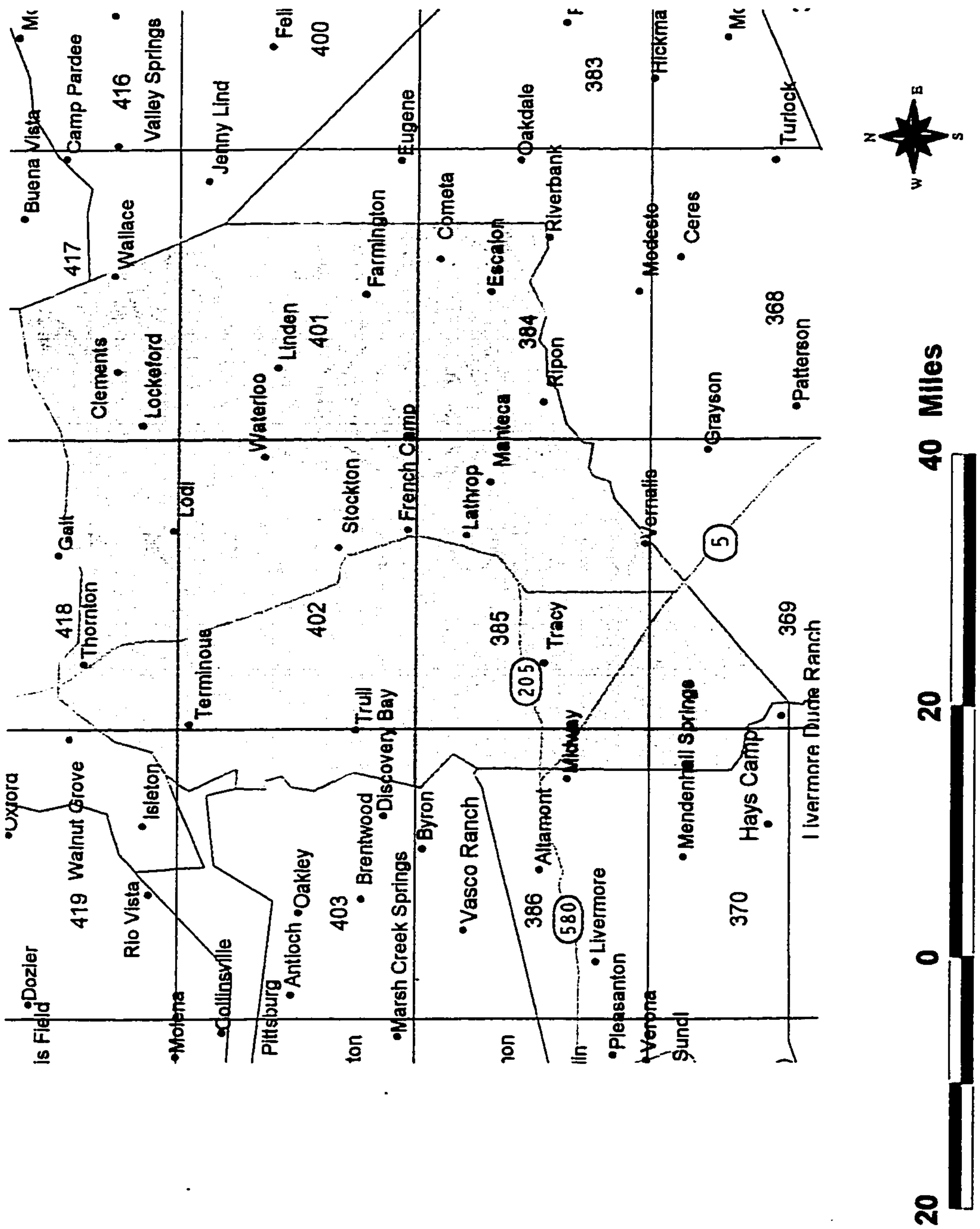


Thermal
Mecca
Valerie
56
Oasis
La Quinta
Taylor
Ribbonwood
57
Thomas Mountain
71
Cahuilla
58
Aguanga
Sage
Murrieta Hot Springs
Temecula
59
Lake Elsinore
Lakeland Village
Wildomar
Trabuco Canyon
San Juan Hot Springs
60
De Luz
San Clemente
San Onofre
Dana Point
Laguna Beach
El Toro
Saltc
43
Ocotillo Well
Borrego Springs
44
Warner Springs
45
Oak Grove
Pauma Valley
Pala
Pala Mesa
Fallbrook
46
Valley Center
Vista
Las Flores
47
Carlsbad
San Marcos
Escondido
Mesa Grande
Santa Ysabel
Julian
Ramona
Rancho Santa Fe
34
Leucadia
Del Mar
35
Station
Blair Valley Ranger
31
32
33
Pine Grove
Mesquite Oasis
Mount Laguna
Pine Valley
Alpine
Lakeside
El Cajon
La Jolla
Linda Vista
22
San Diego
23
Jamul
21
19
Palm Grove
20
Morena Village
Dulzura
Chula Vista
Coronado
Imperial Beach
San Ysidro
Titus
Tierra Del Sol
Tecate
10
9
8
7
Oc
5
15
8
805
N
E
S
W
40
0
40 Miles

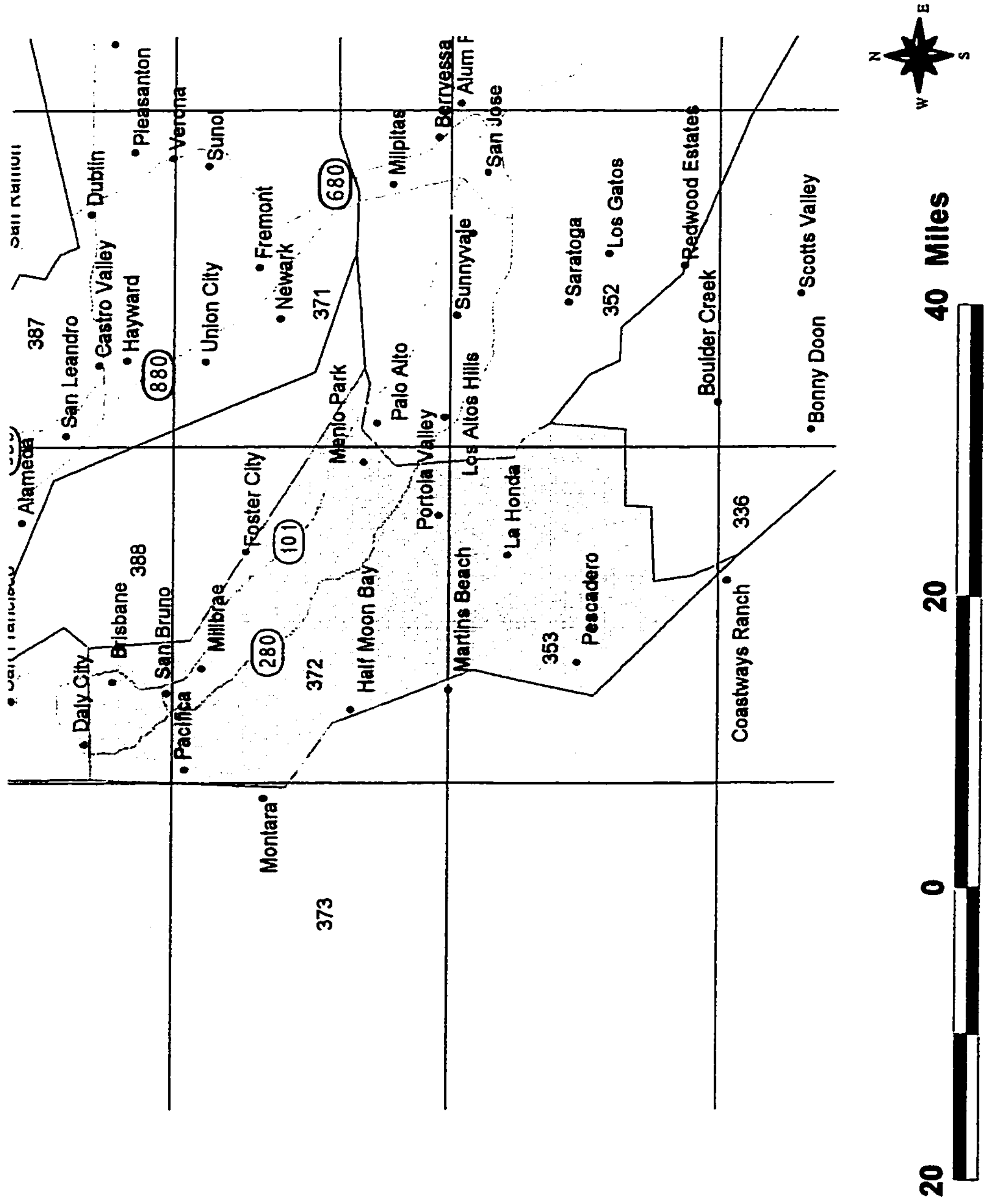
San Francisco Co



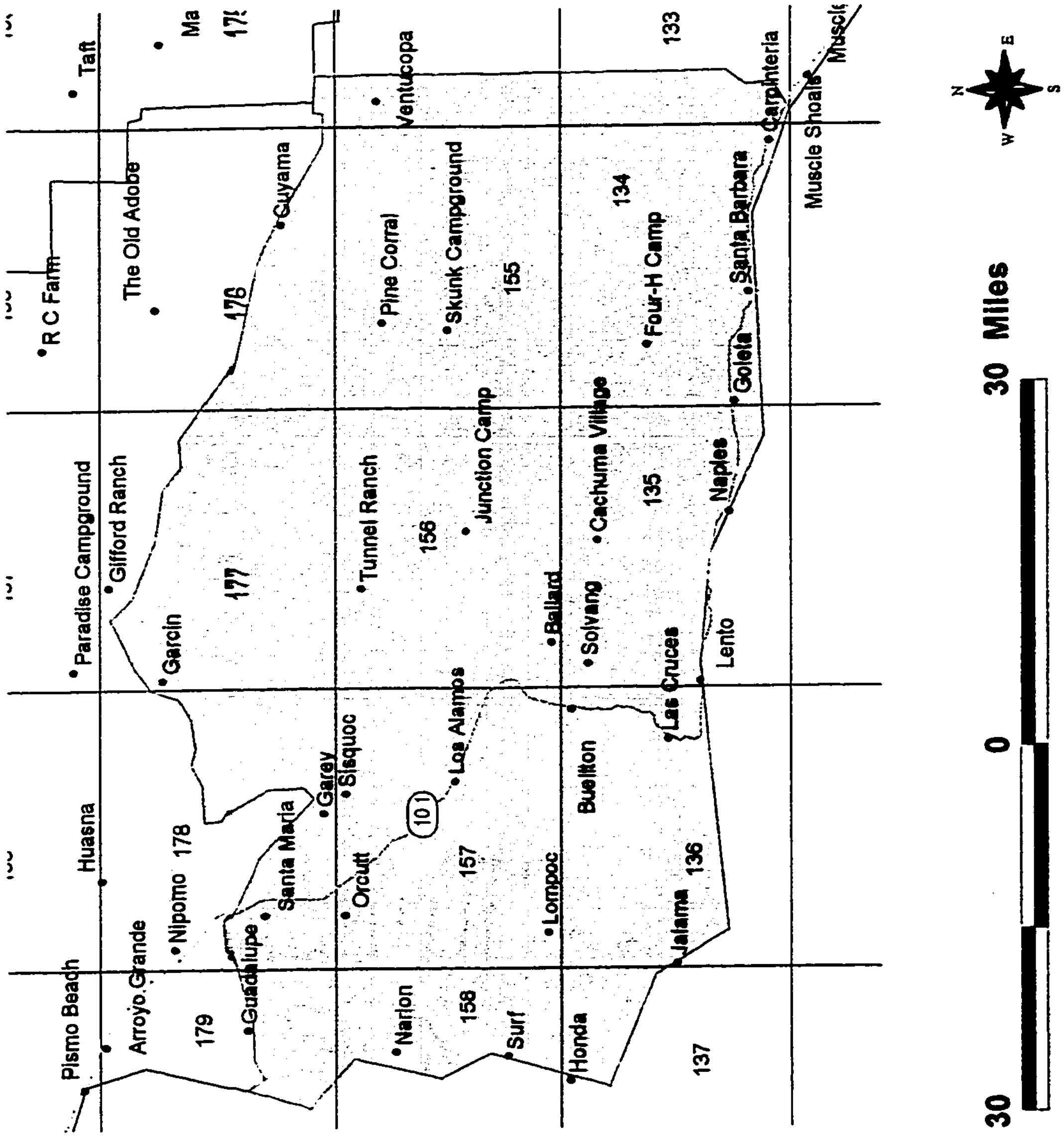
San Joaquin Co



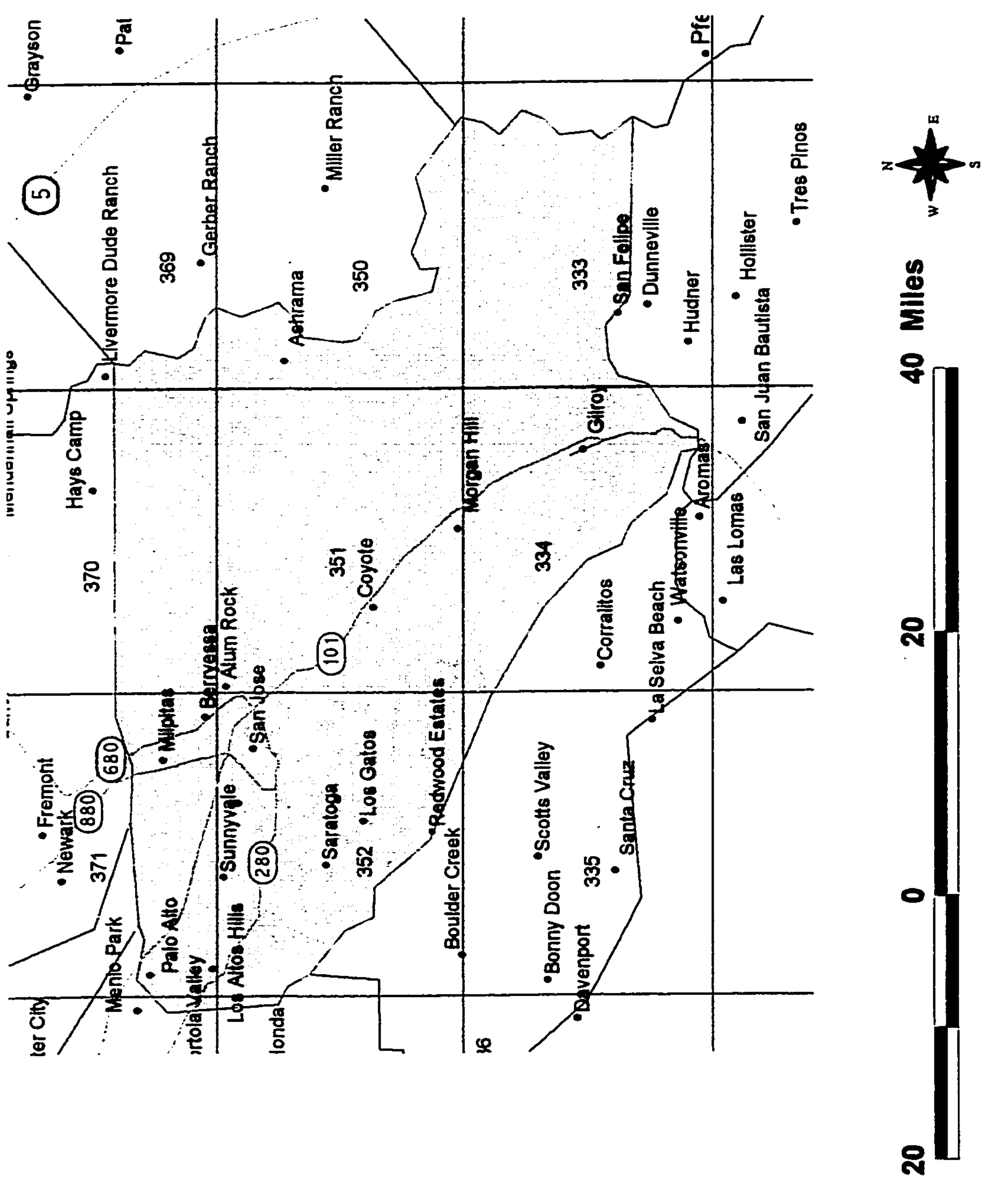
San Luis Obispo Co


Alameda
San Leandro
Castro Valley
Hayward
Dublin
Pleasanton
Verona
Sunol
Union City
Fremont
Newark
Milpitas
Berryessa
Alum R
San Jose
Sunnyvale
Palo Alto
Menlo Park
Foster City
Los Altos Hills
Portola Valley
La Honda
Pescadero
Saratoga
Los Gatos
Redwood Estates
Boulder Creek
Scotts Valley
Bonny Doon
Coastways Ranch
Half Moon Bay
Martins Beach
Millbrae
San Bruno
Brisbane
Daly City
Pacifica
Montara
880
680
101
280
387
388
371
372
373
352
353
336
N
S
E
W
20
0
20
40 Miles

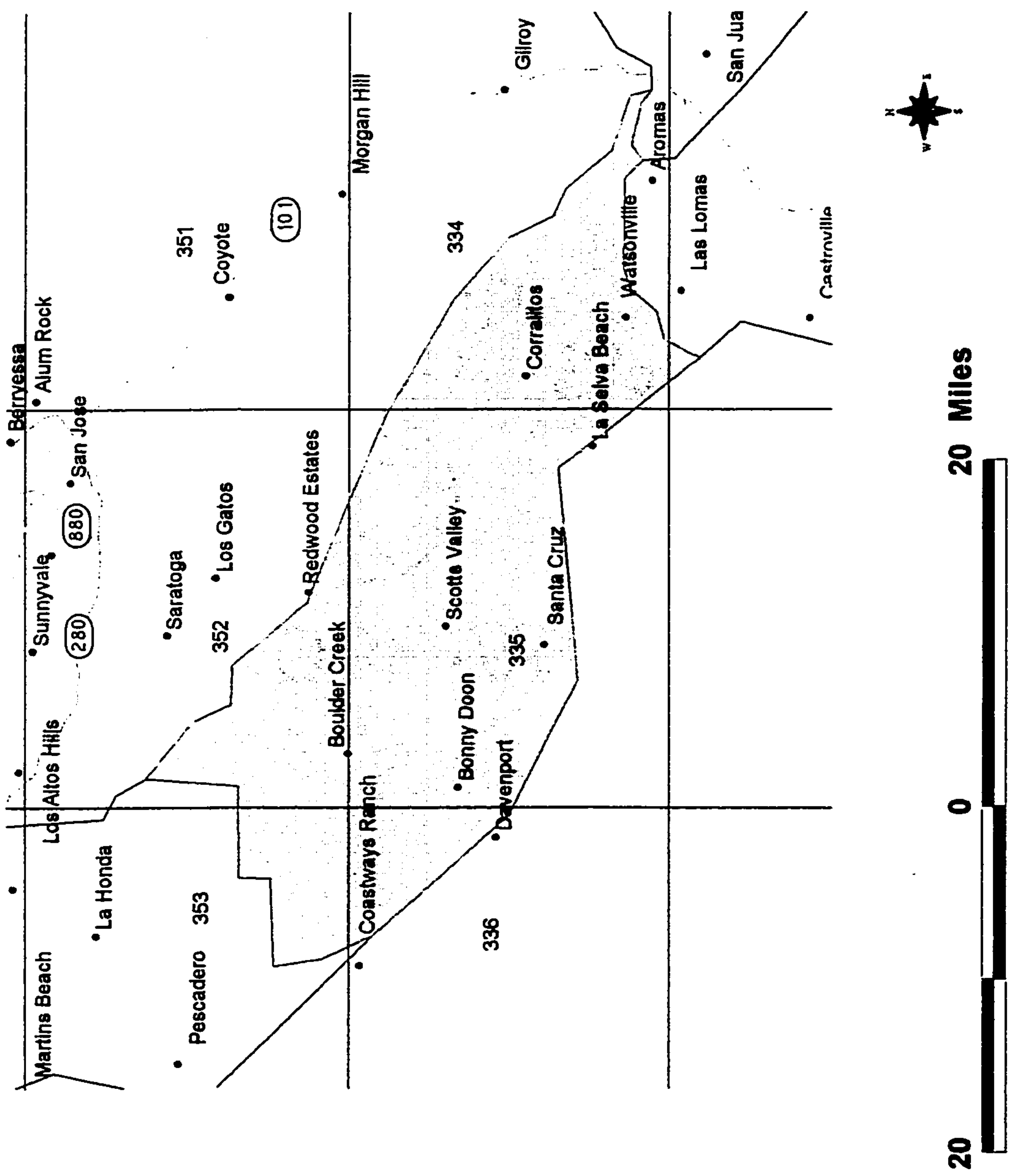
Santa Barbara Co



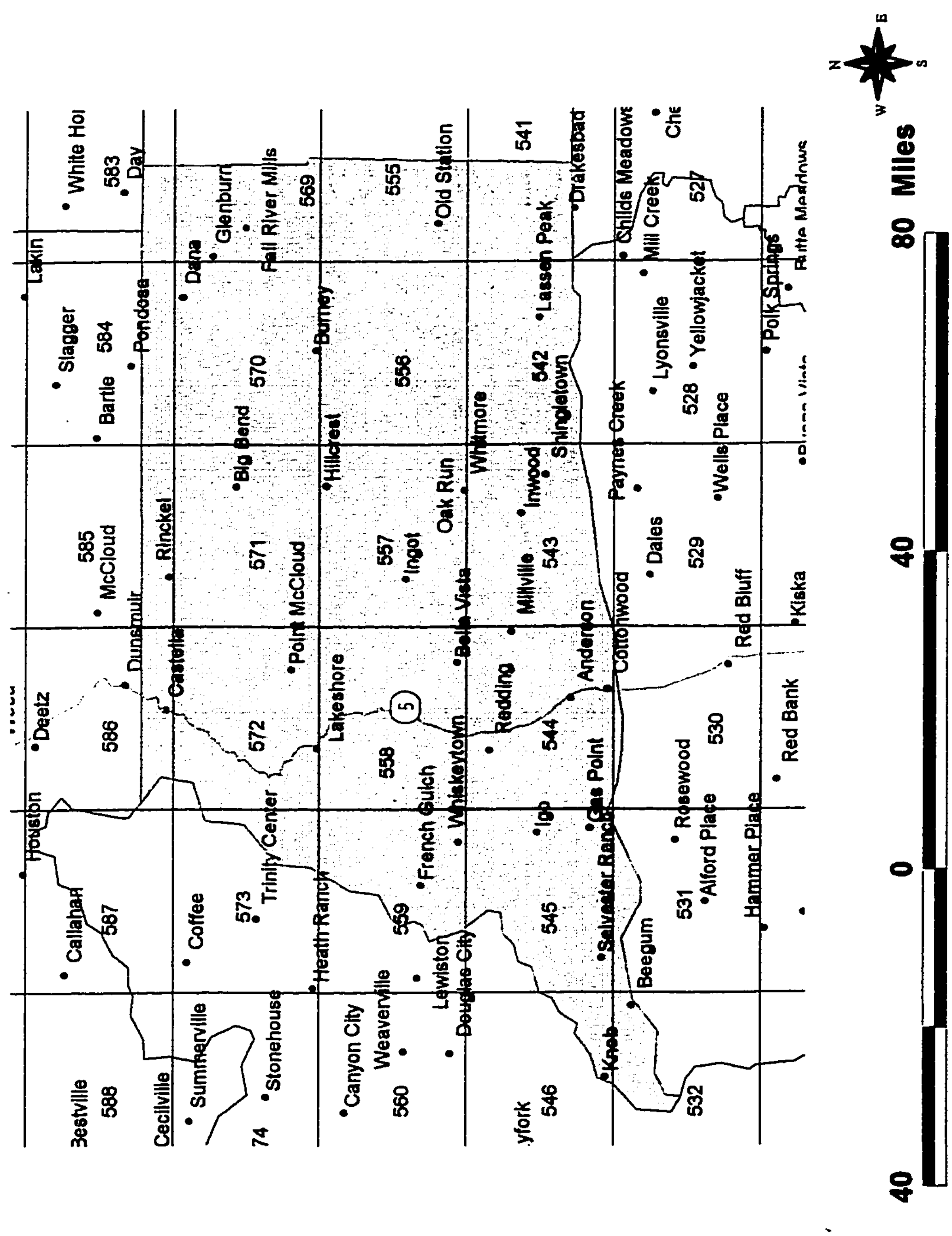
Santa Clara Co



Santa Cruz Co

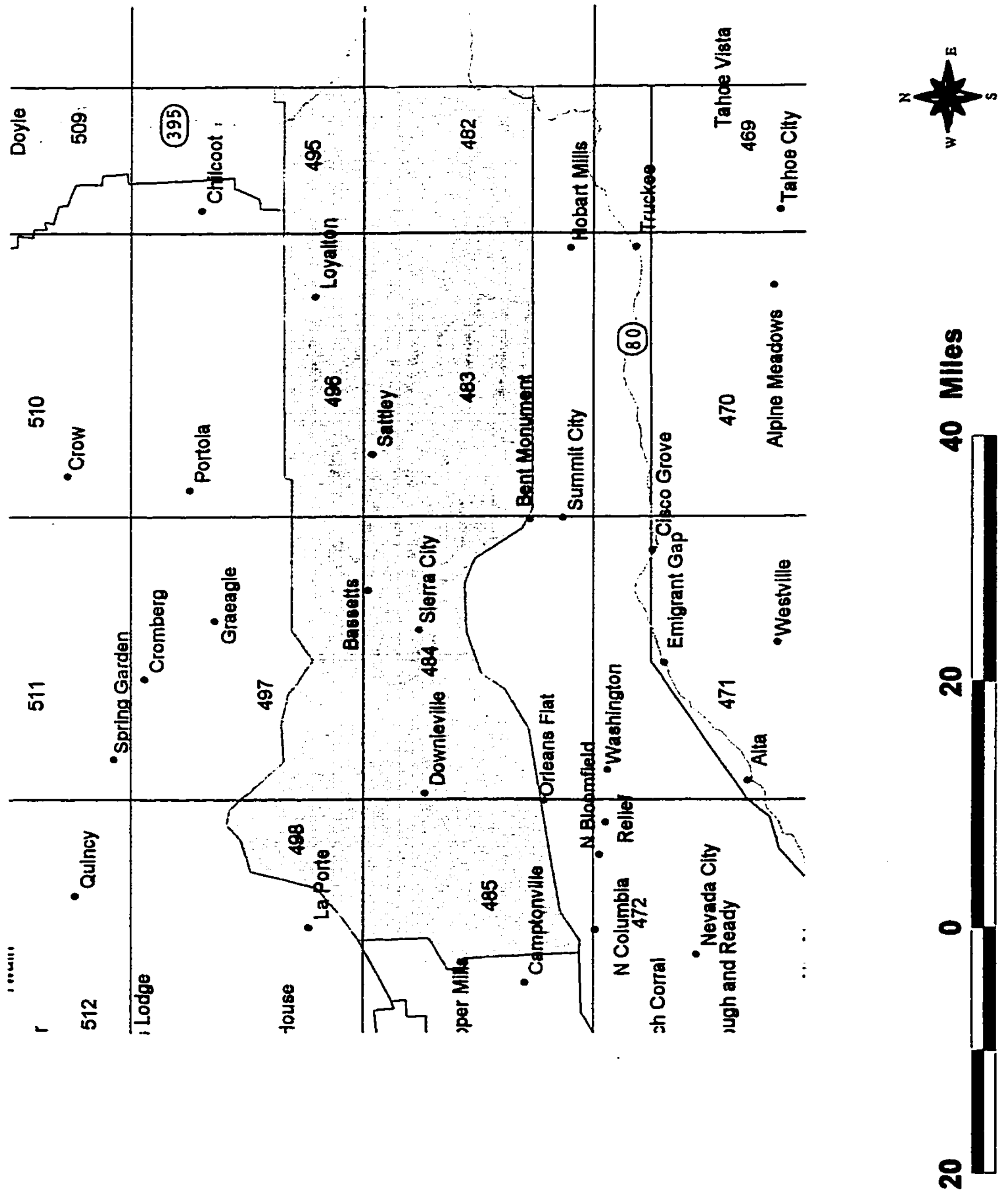


Shasta Co

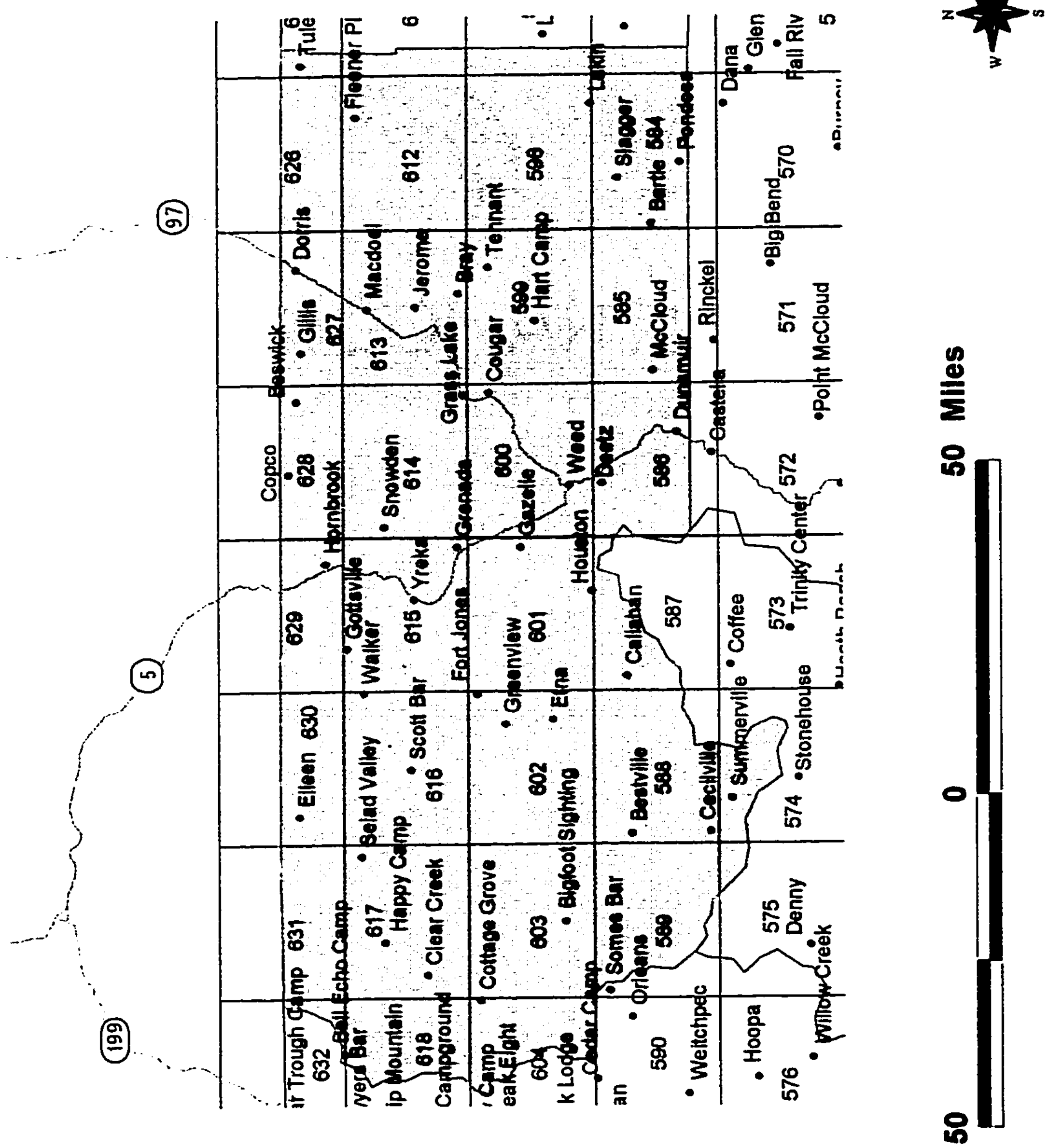


White Hor
583
Day
Lakin
Slagger
Bartle
584
Pondosa
Dana
Glenburn
Fall River Mills
569
570
Burney
555
556
Old Station
541
542
Lassen Peak
Drakesbad
Childs Meadows
Mill Creek
527
Lyonsville
Yellowjacket
528
Polk Springs
Wells Place
Shingletown
Paynes Creek
Whitmore
Inwood
Big Bend
Hillcrest
Oak Run
Ingot
557
571
Rinckel
585
McCloud
Dunsmuir
Castella
Point McCloud
Millville
543
Dales
529
Red Bluff
Kiska
Bella Vista
Anderson
Cottonwood
Redding
Lakeshore
5
572
586
Deetz
544
558
Red Bank
530
Rosewood
Alford Place
Hammer Place
Gas Point
Igo
Whiskeytown
French Gulch
Trinity Center
Houston
Callahan
587
Coffee
573
Heath Ranch
559
545
531
Beegum
Selvester Ranch
Lewiston
Douglas City
Weaverville
Canyon City
Stonehouse
Summerville
Cecilville
588
Bestville
560
546
Knob
532
0
40
80 Miles
N
E
S
W

Sierra Co

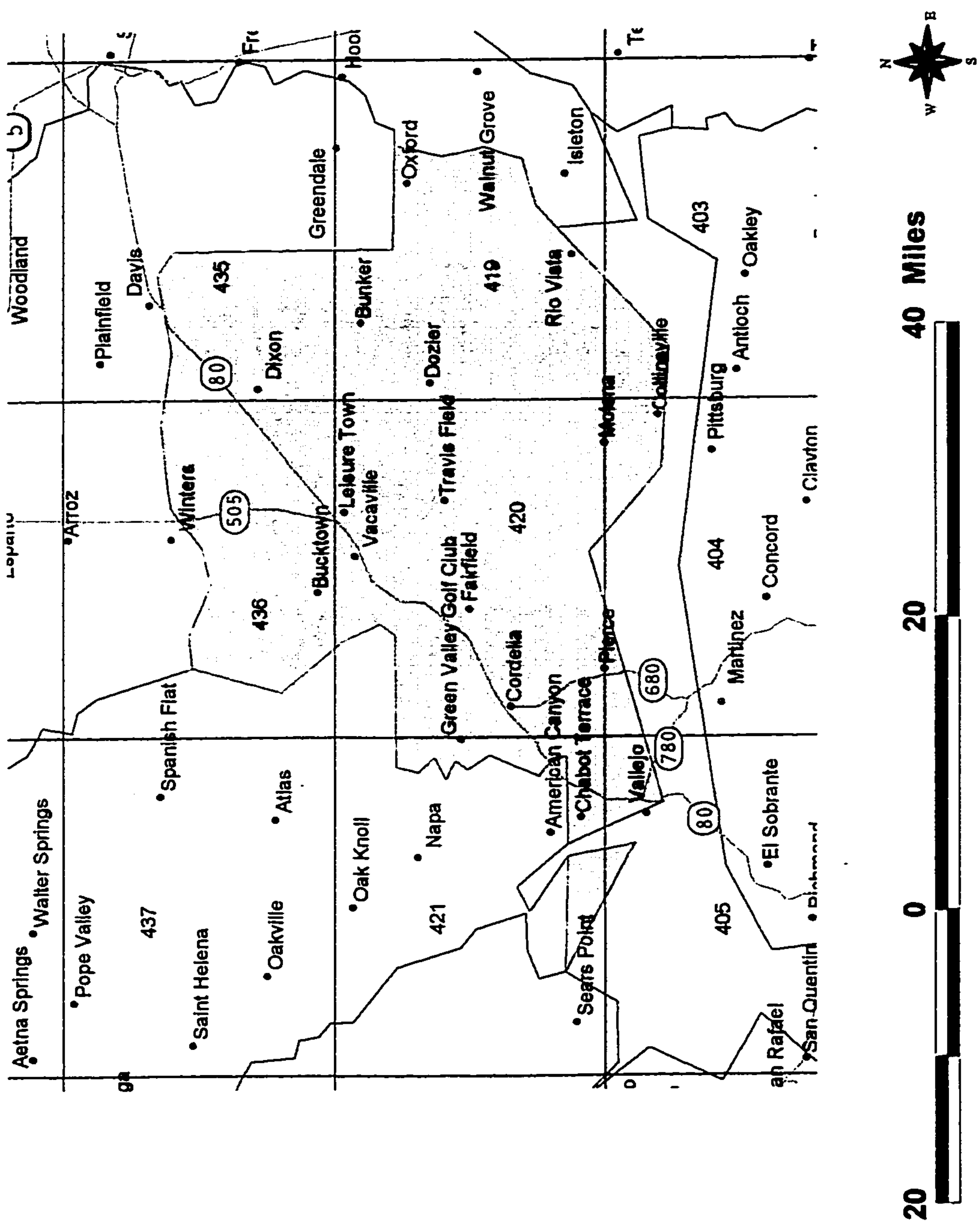

Doyle
509
395
Chilcoot
495
482
Hobart Mills
Truckee
Tahoe Vista
469
Tahoe City
510
Crow
Portola
Loyalton
496
Sattley
483
Bent Monument
Summit City
80
Cisco Grove
470
Alpine Meadows
511
Spring Garden
Cromberg
Graeagle
497
Bassetts
Sierra City
484
Downieville
Orleans Flat
Washington
Emigrant Gap
471
Westville
Alta
512
Quincy
498
La Porte
485
Camptonville
N Bloomfield
Relief
N Columbia
472
Nevada City
Lodge
ch Corral
ugh and Ready
N
E
S
W
40 Miles
20
0
20

Siskiyou Co

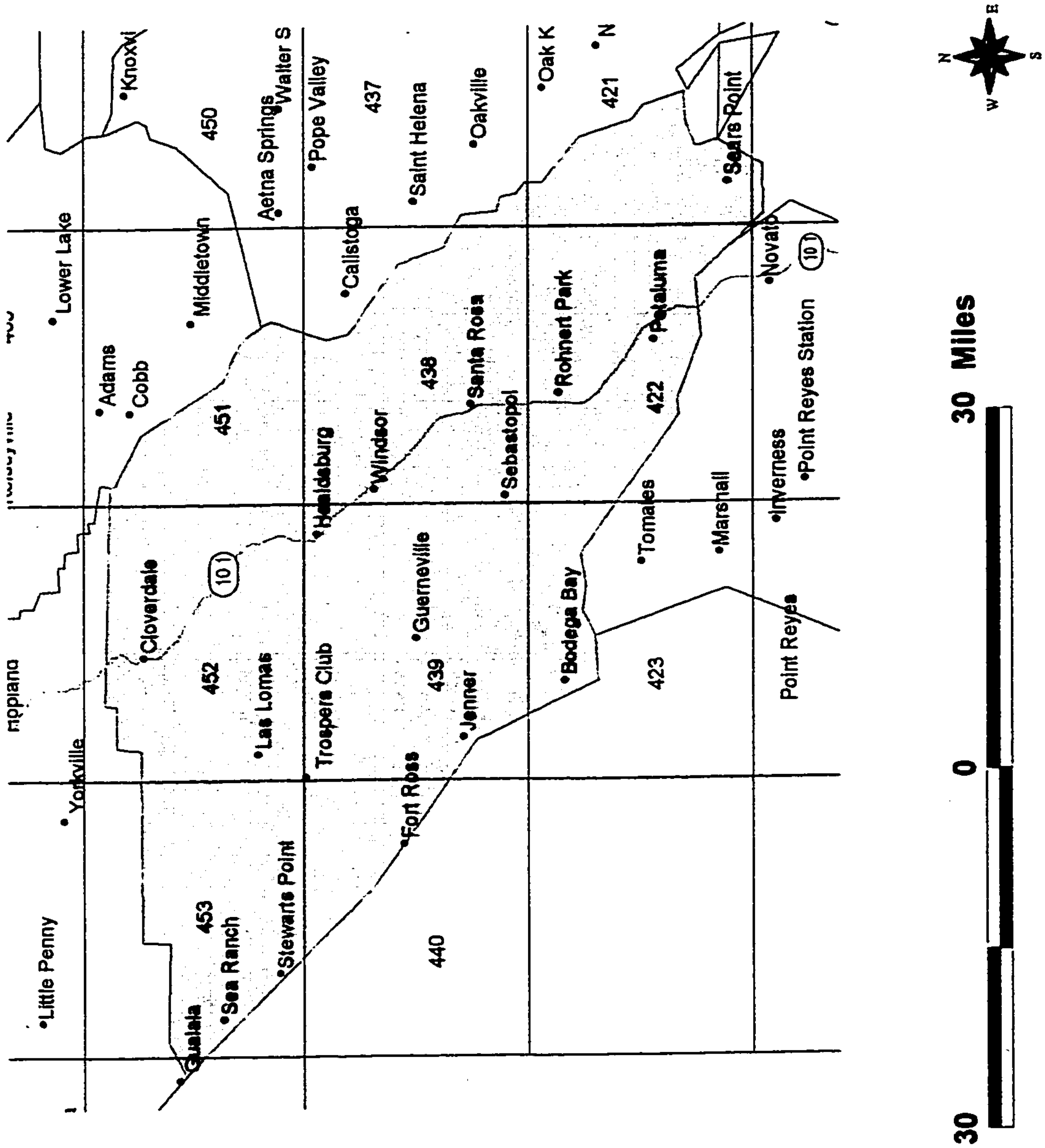


97
5
199
Copco
Hornbrook
Yreka
Gottsville
Walker
Fort Jones
Greenview
Etna
Callahan
Weed
Gazelle
Grenada
Montague
Snowden
Dorris
Macdoel
Tennant
McCloud
Dunsmuir
Castella
Mount Shasta
Happy Camp
Seiad Valley
Scott Bar
Cecilville
Sawyers Bar
Somes Bar
Orleans
Weitchpec
Hoopa
Denny
Willow Creek
Trinity Center
Coffee
Stonehouse
Summerville
Big Bend
Point McCloud
Dana
Glen
Fall Riv
50 Miles
0
50

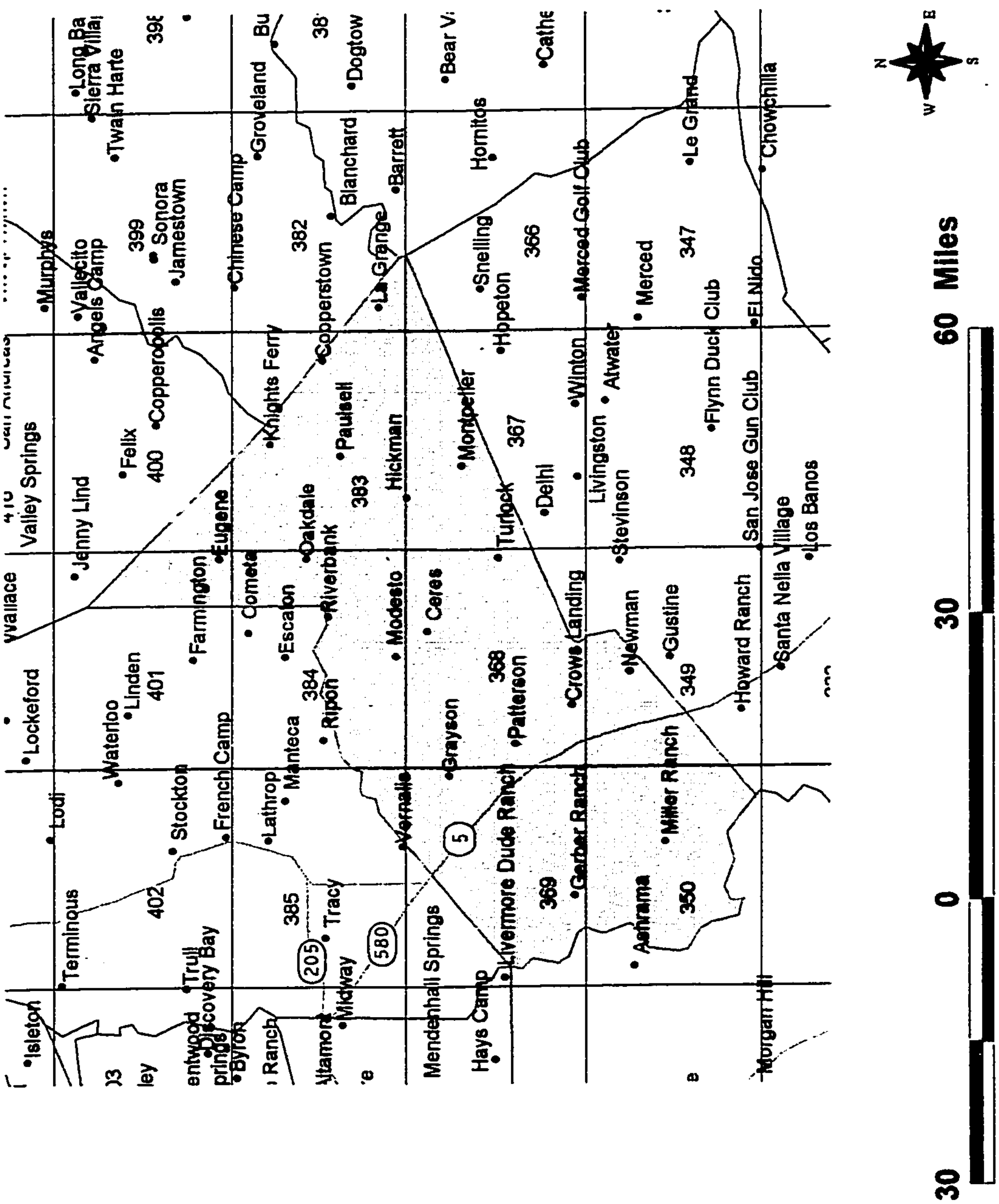
Solano Co


Woodland
Plainfield
Davis
435
Greendale
Oxford
Walnut Grove
Isleton
Dixon
80
Bunker
Dozier
419
Rio Vista
403
Oakley
Antioch
Collinsville
Pittsburg
Montezuma
Travis Field
Leisure Town
Vacaville
Winters
505
Arroz
Bucktown
436
Fairfield
Green Valley Golf Club
420
404
Concord
Clayton
Cordelia
Martinez
680
Spanish Flat
American Canyon
Chabot Terrace
Vallejo
780
El Sobrante
Atlas
Napa
Oak Knoll
421
Walter Springs
Pope Valley
437
Saint Helena
Oakville
Aetna Springs
Sears Point
405
San Quentin
N
S
E
W
0
20
40
Miles

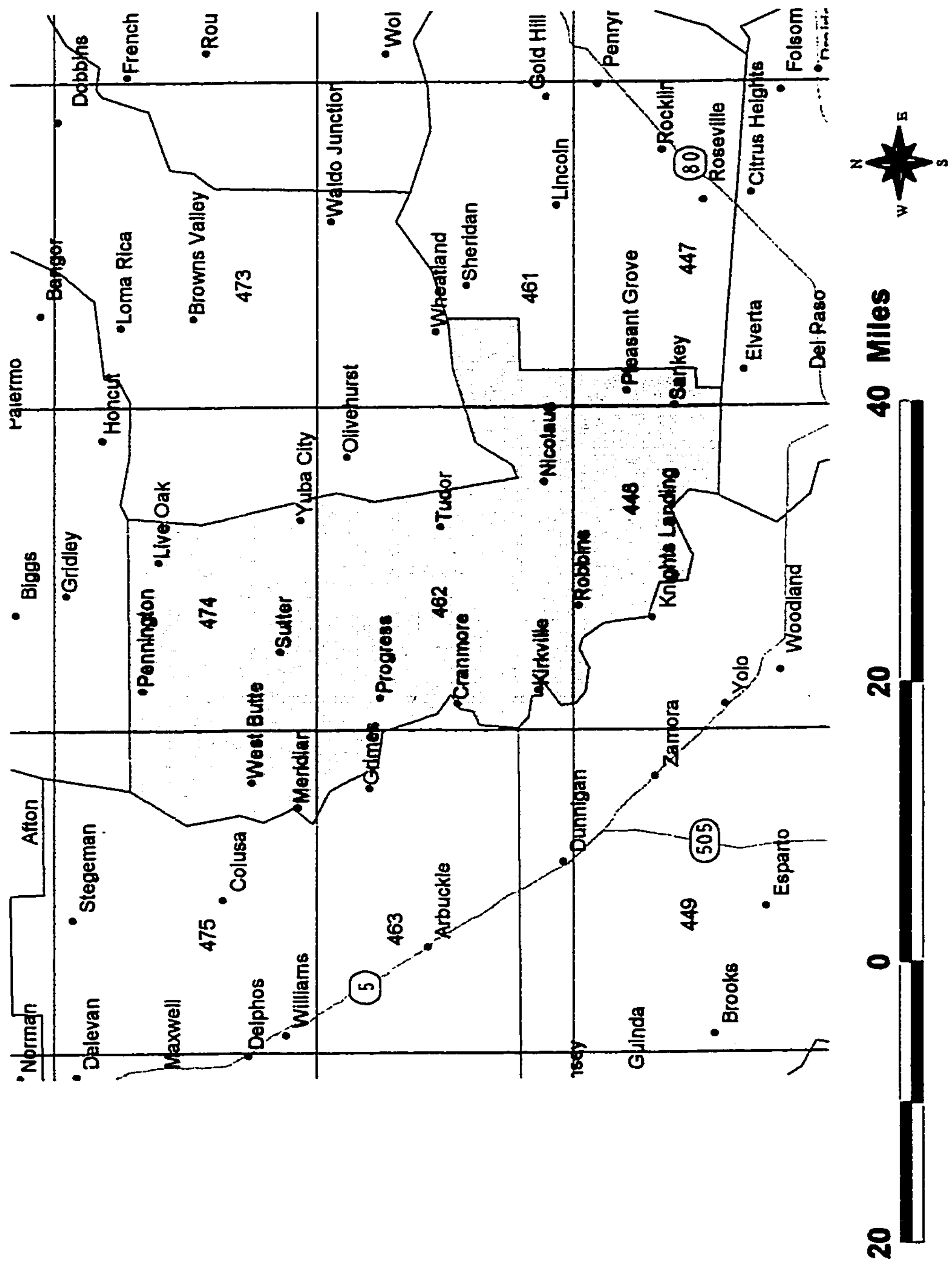
Sonoma Co


Little Penny
Yorkville
Gualala
Sea Ranch
453
Stewarts Point
440
Fort Ross
Jenner
439
Trospers Club
Las Lomas
452
Cloverdale
101
Guerneville
Bodega Bay
423
Point Reyes
Tomales
Marshall
Inverness
Point Reyes Station
Healdsburg
Windsor
Sebastopol
438
Santa Rosa
Rohnert Park
422
Petaluma
Novato
101
451
Adams
Cobb
Middletown
Lower Lake
Calistoga
Aetna Springs
450
Knoxvi
Walter S
Pope Valley
437
Saint Helena
Oakville
Oak K
421
Sears Point
30
0
30 Miles

Stanislaus Co

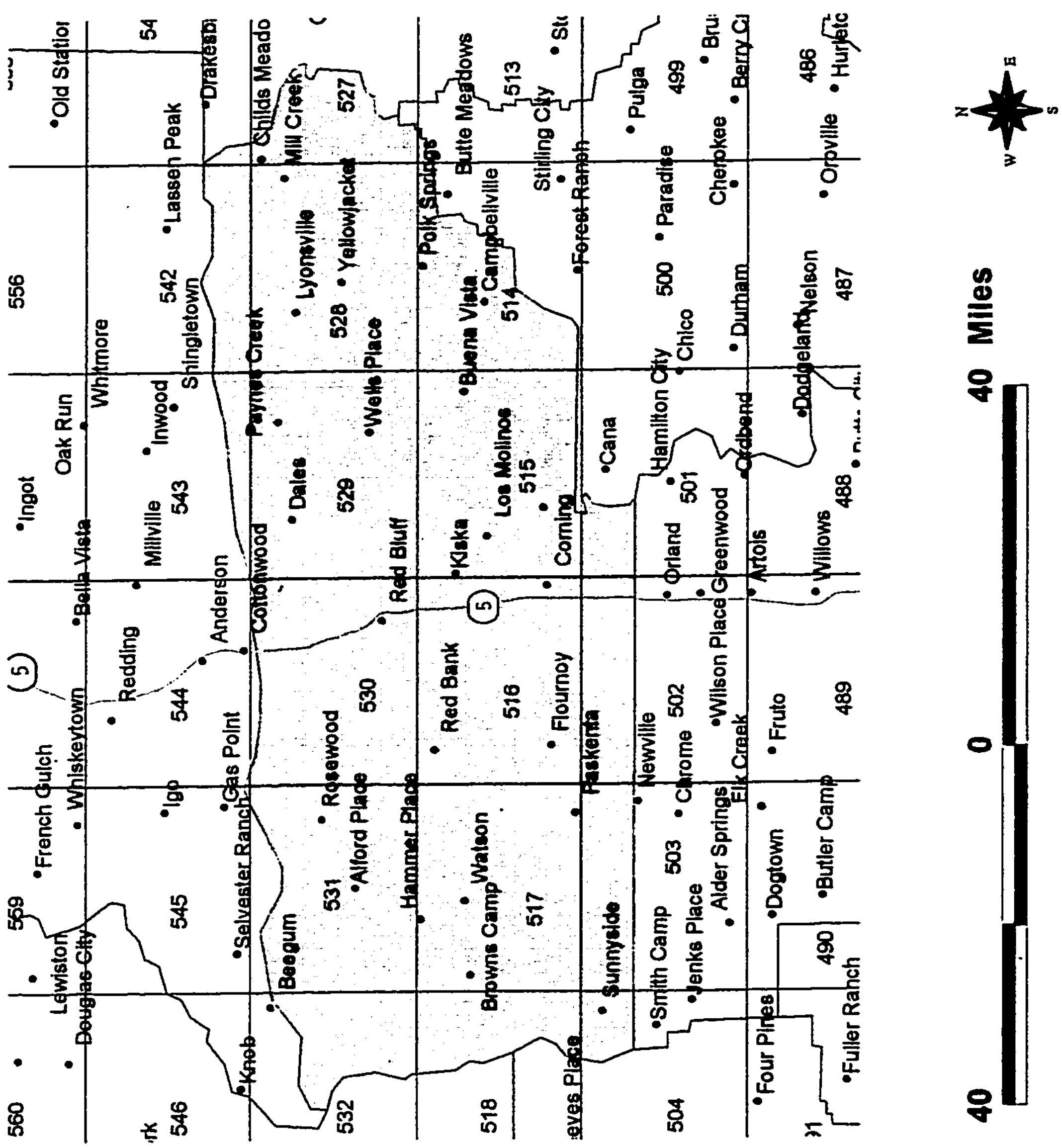


Sutter Co



Dobbins
French
Rou
Wol
Gold Hill
Penryn
Folsom
Waldo Junction
Lincoln
Rocklin
80
Roseville
Citrus Heights
Bangor
Loma Rica
Browns Valley
473
Wheatland
Sheridan
461
Pleasant Grove
447
Elverta
Del Paso
Palermo
Honcut
Olivehurst
Nicolaus
Sankey
Biggs
Gridley
Live Oak
Yuba City
Tudor
448
Knights Landing
Pennington
474
Sutter
Progress
462
Cranmore
Robbins
Kirkville
Woodland
Yolo
West Butte
Meridian
Gilmer
Zamora
Afton
Stegeman
Colusa
Dunnigan
505
Esparto
475
463
Arbuckle
449
Norman
Delevan
Maxwell
Delphos
Williams
5
Glinda
Brooks
N
E
S
W
Miles
20
0
20
40

Tehama Co



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Lassen Peak
Childs Meadows
Mill Creek
Lyonsville
Yellowjacket
Polk Springs
Butte Meadows
Campbellville
Stirling City
Forest Ranch
Pulga
Paradise
Cherokee
Oroville
Whitmore
Oak Run
Ingot
Inwood
Shingletown
Paynes Creek
Dales
Wells Place
Buena Vista
Los Molinos
Hamilton City
Chico
Durham
Dodgeland
Nelson
Cana
Ordbend
Orland
Greenwood
Artois
Willows
Bella Vista
Millville
Anderson
Cottonwood
Red Bluff
Kiska
Corning
Redding
Whiskeytown
French Gulch
Igo
Gas Point
Rosewood
Alford Place
Hammer Place
Red Bank
Flournoy
Paskenta
Newville
Chrome
Wilson Place
Elk Creek
Alder Springs
Fruto
Butler Camp
Dogtown
Jenks Place
Smith Camp
Sunnyside
Watson
Browns Camp
Beegum
Selvester Ranch
Lewiston
Douglas City
Knob
Four Pines
Fuller Ranch
5
556
542
543
544
545
546
559
560
527
528
529
530
531
532
513
514
515
516
517
518
499
500
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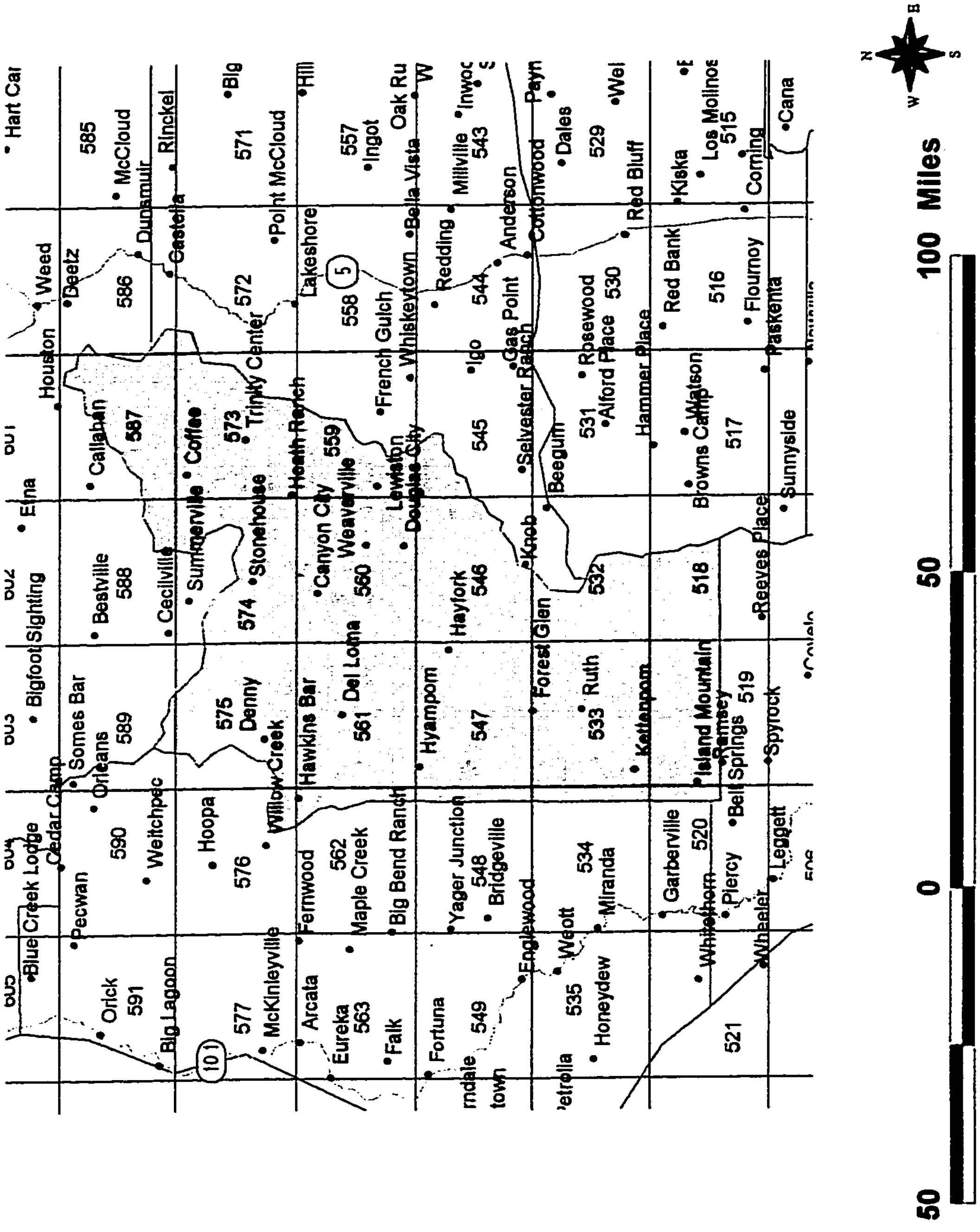
502
503
504
486
487
488
489
490
N
S
E
W
40
0
40 Miles

Trinity Co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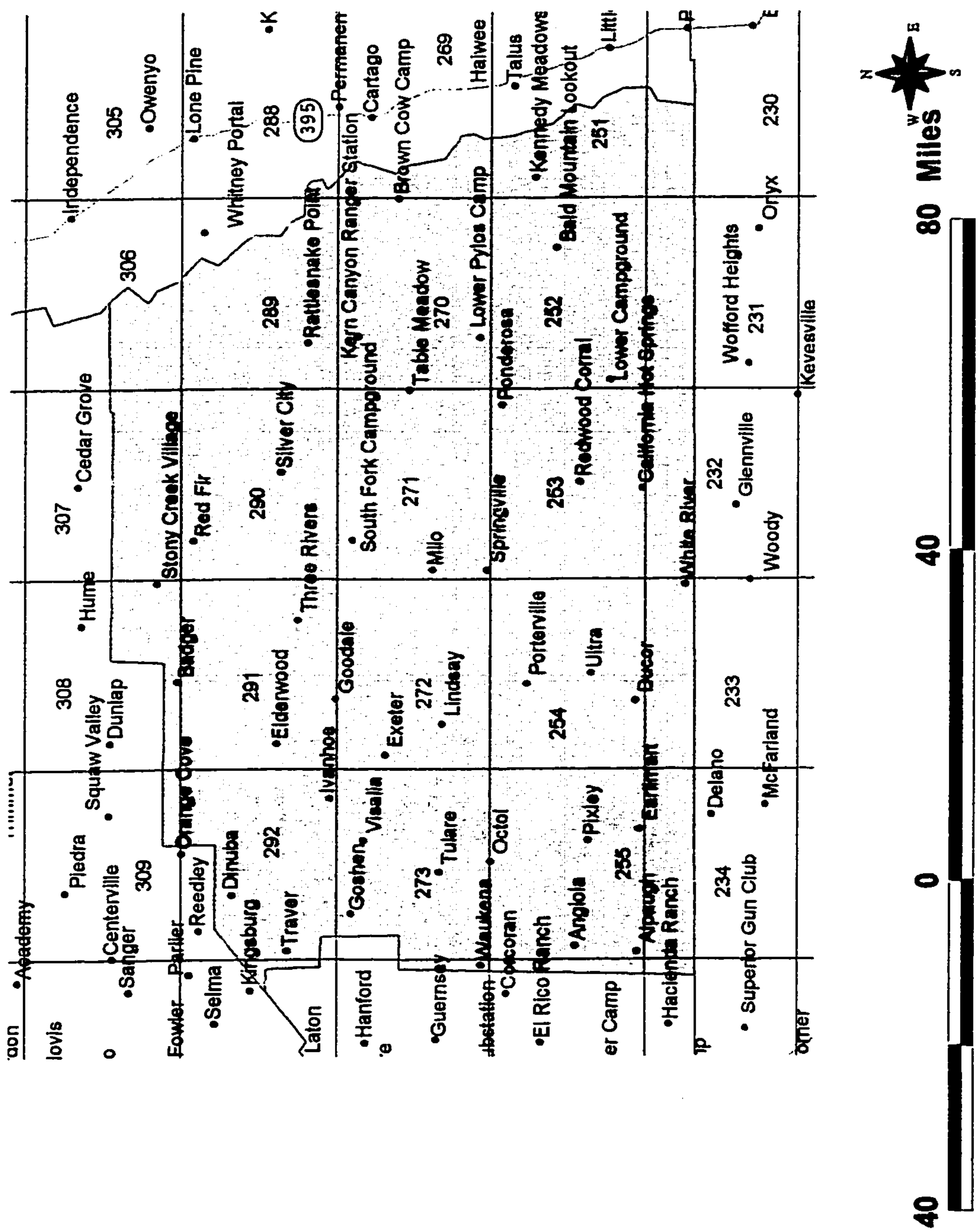
Houston
Callahan
Coffee
Trinity Center
Heath Ranch
Canyon City
Weaverville
Lewiston
Douglas City
French Gulch
Whiskeytown
Redding
Igo
Gas Point
Anderson
Cottonwood
Summerville
Stonehouse
Cecilville
Bestville
Hayfork
Forest Glen
Knob
Beegum
Hyampom
Del Loma
Hawkins Bar
Denny
Willow Creek
Ruth
Kettenpom
Island Mountain
Hoopa
Weitchpec
Orleans
Somes Bar
Bigfoot Sighting
Cedar Camp
Blue Creek Lodge
Pecwan
Orick
Big Lagoon
McKinleyville
Arcata
Eureka
Fernwood
Maple Creek
Big Bend Ranch
Yager Junction
Bridgeville
Fortuna
Falk
Englewood
Weott
Miranda
Honeydew
Garberville
Whitethorn
Piercy
Bell Springs
Leggett
Spyrock
Reeves Place
Sunnyside
Browns Camp
Watson
Paskenta
Flournoy
Red Bank
Red Bluff
Hammer Place
Alford Place
Rosewood
Selvester Ranch
Dales
Corning
Los Molinos
Kiska
Millville
Bella Vista
Ingot
Lakeshore
Point McCloud
Castella
Dunsmuir
McCloud
Rinckel
Beetz
Etna
101
5
0
50
100 Miles

Tulare Co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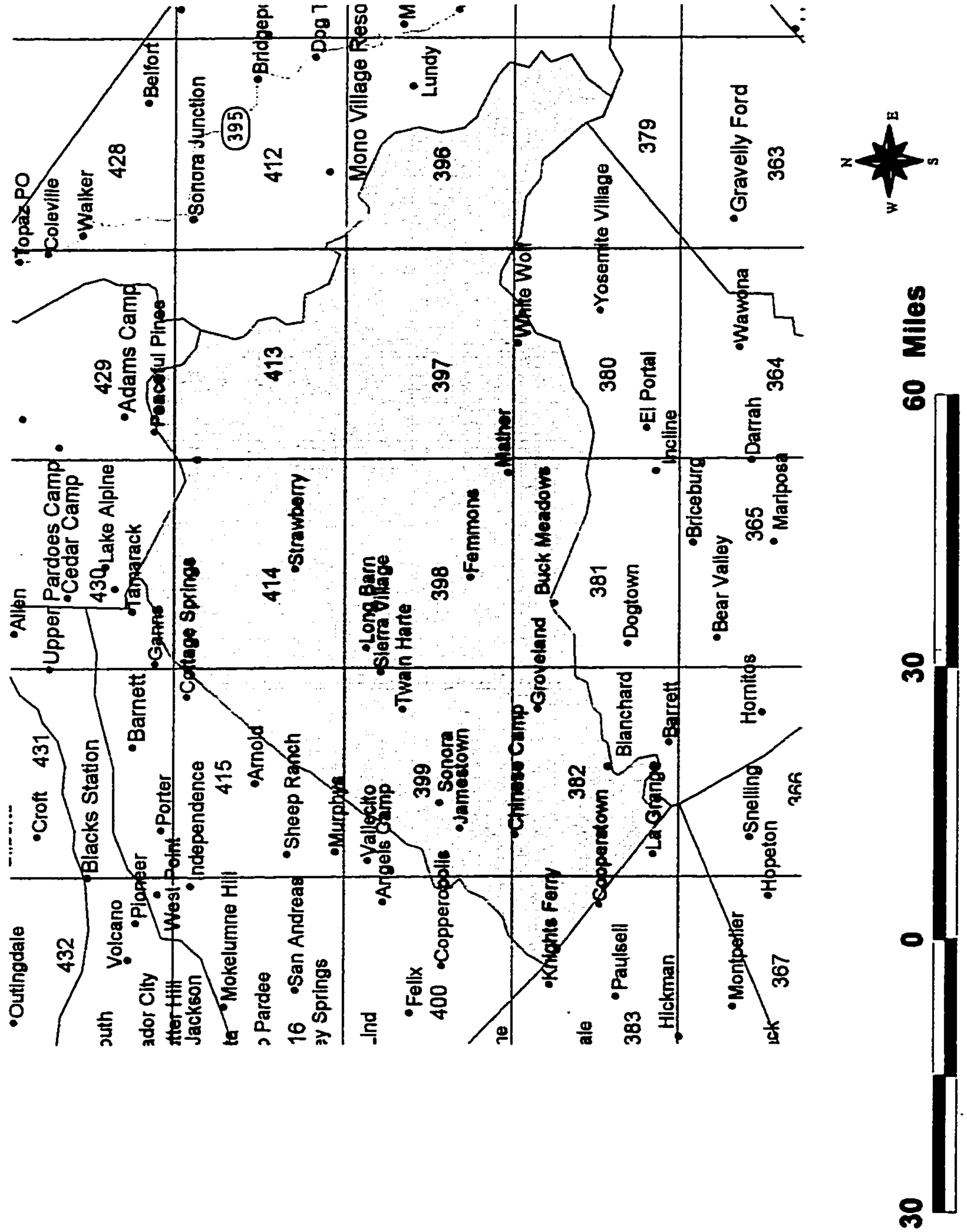
Owenyo
Lone Pine
Whitney Portal
395
Cartago
Brown Cow Camp
Haiwee
Talus
Kennedy Meadows
Bald Mountain Lookout
Onyx
Wofford Heights
Keyesville
Rattlesnake Point
Kern Canyon Ranger Station
Table Meadow
Lower Pylos Camp
Ponderosa
Lower Campground
Redwood Corral
California Hot Springs
Cedar Grove
Stony Creek Village
Red Fir
Silver City
South Fork Campground
Three Rivers
Milo
Springville
Glennville
White River
Woody
Hume
Squaw Valley
Dunlap
Badger
Elderwood
Goodale
Exeter
Lindsay
Porterville
Ultra
Ducor
Delano
McFarland
Piedra
Centerville
Sanger
Orange Cove
Reedley
Dinuba
Traver
Kingsburg
Selma
Fowler
Parlier
Ivanhoe
Visalia
Goshen
Tulare
Octol
Waukena
Corcoran
Pixley
Earlimart
Angiola
Alpaugh
Hacienda Ranch
El Rico Ranch
Guernsey
Hanford
Laton
Superior Gun Club
Academy
305
306
307
308
309
288
289
290
291
292
269
270
271
272
273
251
252
253
254
255
230
231
232
233
234
N
S
E
W
Miles
0
40
80

Tuolumne Co



Outingdale
432
Volcano
Pioneer
West Point
Jackson
Mokelumne Hill
Pardee
San Andreas
Felix
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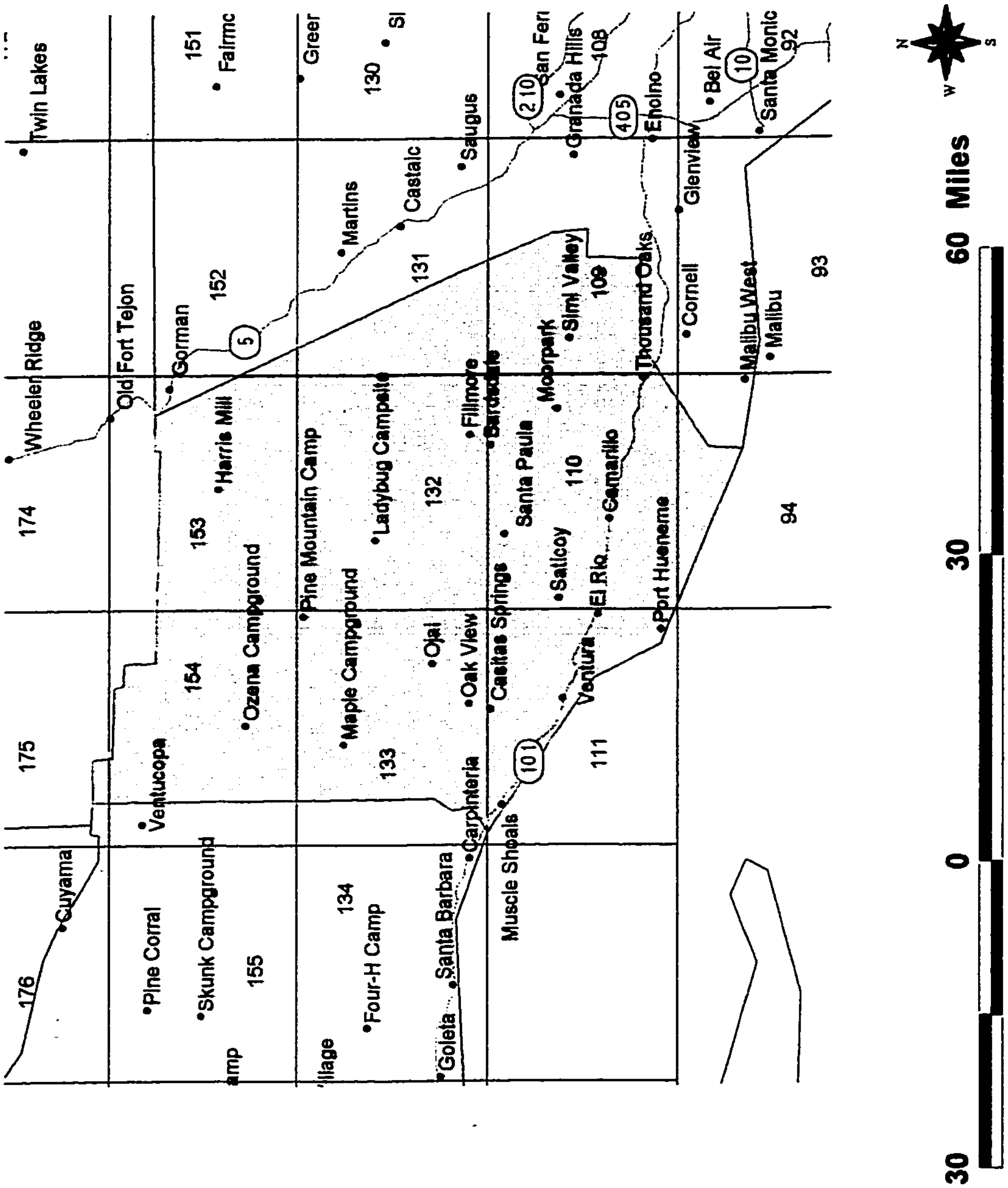
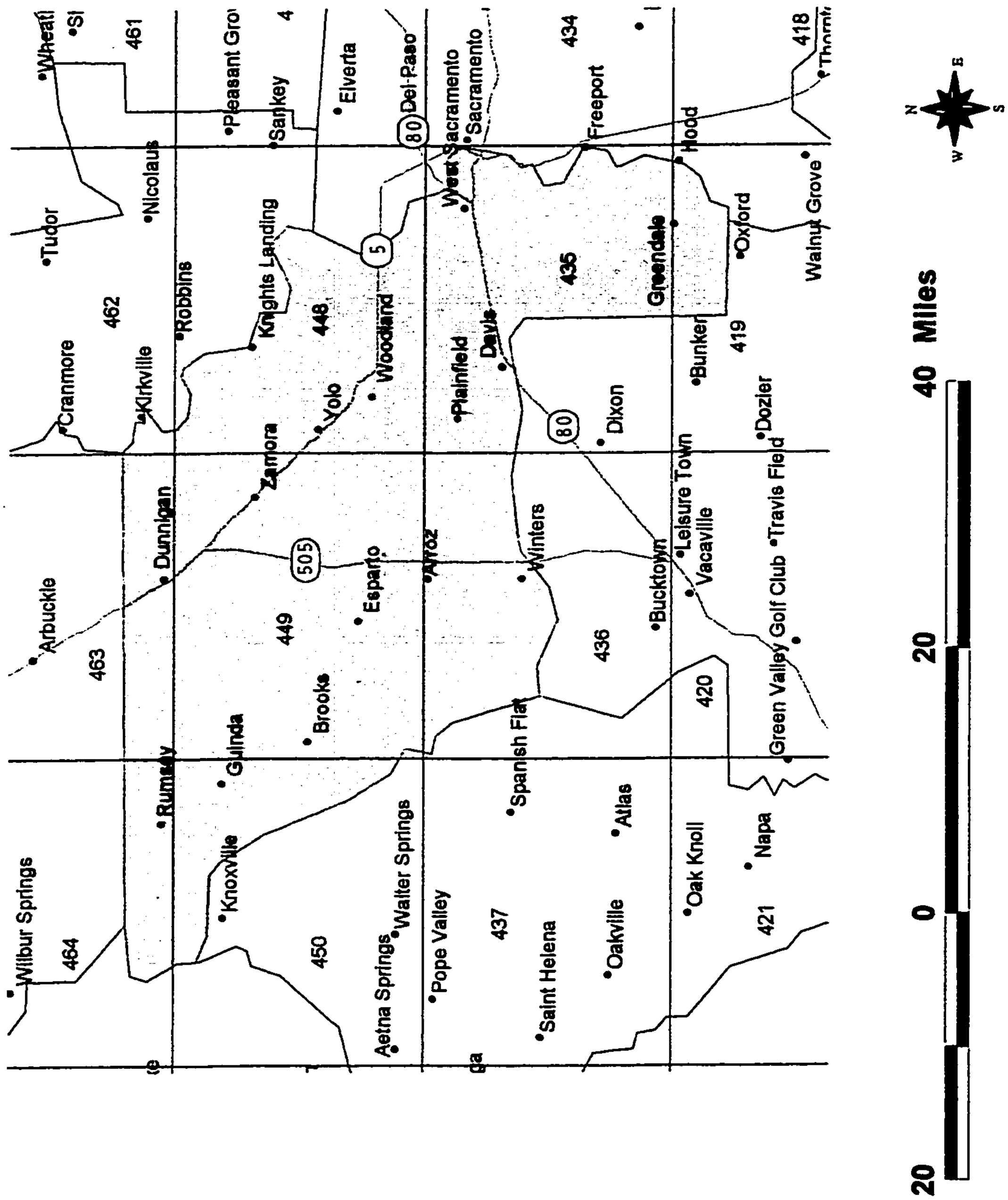
Copperopolis
Knights Ferry
Paulsell
383
Hickman
Montpelier
367
Blacks Station
Croft
431
Porter
Independence
415
Arnold
Sheep Ranch
Murphys
Vallecito
Angels Camp
399
Sonora
Jamestown
Chinese Camp
382
La Grange
Snelling
Hopeton
Barnett
Cottage Springs
Twain Harte
Groveland
Blanchard
Barrett
Hornitos
Allen
Upper Pardoes Camp
Cedar Camp
430
Lake Alpine
Tamarack
Long Barn
Sierra Village
414
Strawberry
398
Femmons
Buck Meadows
381
Dogtown
Bear Valley
Briceburg
365
Mariposa
Mather
429
Adams Camp
Peaceful Pines
413
397
380
El Portal
Incline
Darrah
364
White Wolf
Yosemite Village
Wawona
Topaz PO
Coleville
Walker
428
Sonora Junction
395
412
Belfort
Bridgeport
396
Lundy
379
Gravelly Ford
363
N
E
S
W
30
0
30
60 Miles

Ventura Co



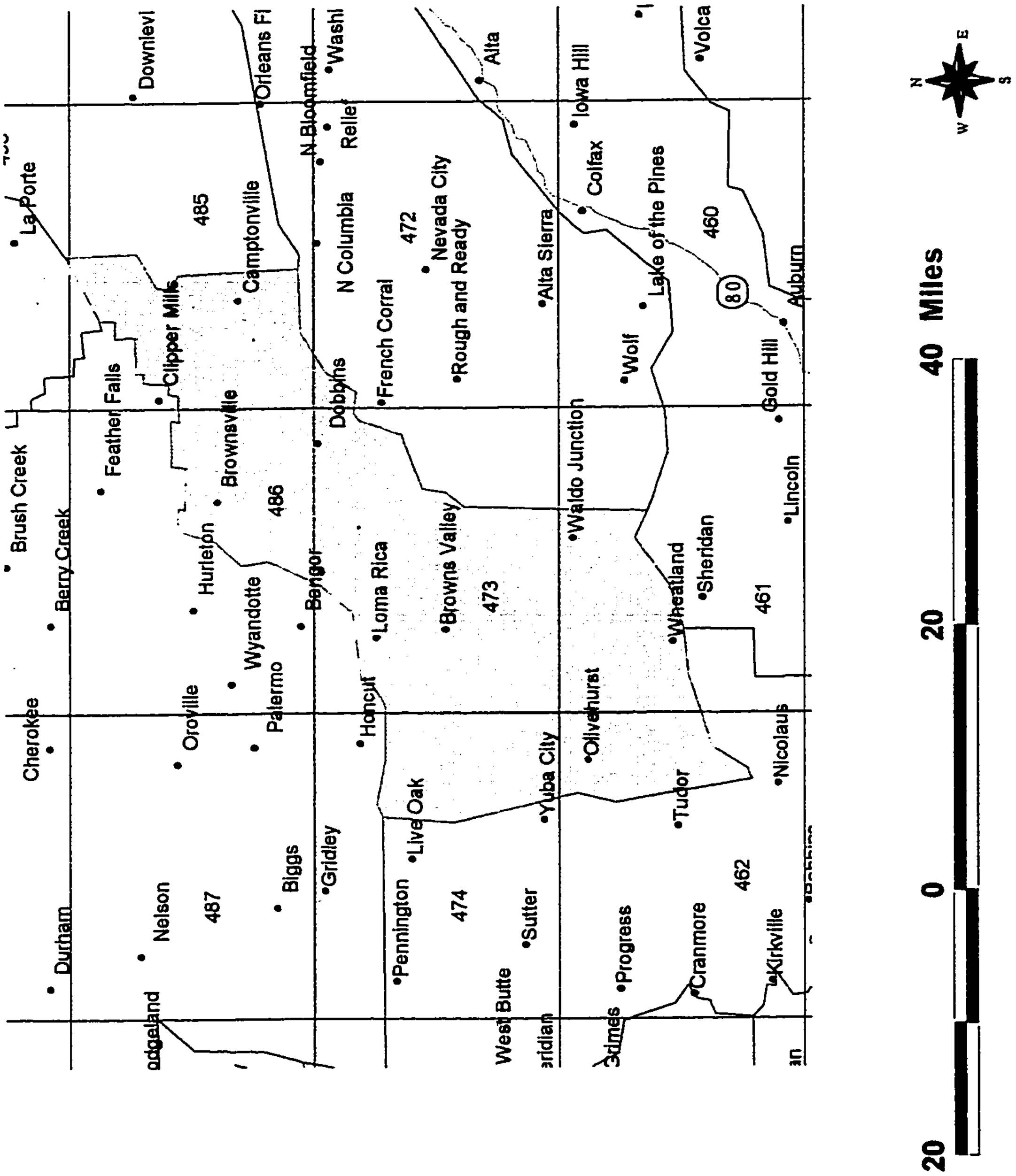
Twin Lakes
Wheeler Ridge
Old Fort Tejon
Gorman
Cuyama
Ventucopa
Pine Corral
Skunk Campground
Harris Mill
Pine Mountain Camp
Ozena Campground
Maple Campground
Ladybug Campsite
Four-H Camp
Santa Barbara
Goleta
Carpinteria
Muscle Shoals
Ojai
Oak View
Casitas Springs
Fillmore
Bardsdale
Santa Paula
Saticoy
Ventura
El Rio
Camarillo
Port Hueneme
Moorpark
Simi Valley
Thousand Oaks
Cornell
Malibu West
Malibu
Glenview
Encino
Granada Hills
San Fern
Saugus
Castaic
Martins
Greer
Fairmo
Bel Air
Santa Monic
151
152
153
154
155
130
131
132
133
134
108
109
110
111
92
93
94
174
175
176
5
101
210
405
10
0
30
60
Miles
30
N
E
S
W

Yolo Co



Wilbur Springs
464
Knoxville
Rumsey
Guinda
Brooks
463
Arbuckle
449
505
Esparto
Dunnigan
Zamora
Yolo
Woodland
448
Knights Landing
Robbins
Kirkville
Cranmore
462
Tudor
Nicolaus
461
Pleasant Gro
Sankey
Elverta
80
Del Paso
West Sacramento
Sacramento
5
Plainfield
Davis
80
Dixon
435
Greendale
Freeport
434
Hood
Oxford
Walnut Grove
418
Bunker
419
Dozier
Travis Field
Leisure Town
Vacaville
Bucktown
Winters
436
Arroz
Green Valley Golf Club
420
Spanish Flat
Atlas
Napa
Oak Knoll
421
Oakville
Saint Helena
437
Pope Valley
Walter Springs
Aetna Springs
450
Miles
40
20
0
20

Yuba Co



La Porte
Downievl
Orleans Fl
Washi
N Bloomfield
Relief
Alta
Iowa Hill
Volca
Colfax
Lake of the Pines
460
Auburn
80
485
Camptonville
N Columbia
472
Nevada City
Rough and Ready
French Corral
Alta Sierra
Wolf
Gold Hill
Clipper Mills
Feather Falls
Brownsville
Dobbins
Brush Creek
Berry Creek
Hurleton
486
Bangor
Loma Rica
Browns Valley
473
Waldo Junction
Wheatland
Sheridan
461
Lincoln
Cherokee
Oroville
Wyandotte
Palermo
Honcut
Yuba City
Olivehurst
Tudor
Nicolaus
Durham
Nelson
487
Biggs
Gridley
Live Oak
Pennington
474
Sutter
West Butte
Progress
Cranmore
462
Kirkville
Miles
40
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APPENDIX B

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
1		X		X				X	X	X	X	42	28
2			X	X			X		X	X	X	42	28
3			X	X			X		X	X	X	42	28
4			X	X			X		X	X	X	42	28
5			X	X			X		X	X	X	42	28
6			X	X			X		X	X	X	42	28
7			X	X			X		X	X	X	42	28
8		X		X			X		X	X	X	42	28
9	X			X			X		X	X	X	42	28
10				X		X						42	28
11				X		X				X		42	28
12				X		X				X		42	28
13		X		X				X	X	X	X	43	28
14		X		X				X	X	X	X	43	28
15			X	X			X		X	X	X	43	28
16			X	X			X		X	X	X	43	28
17			X	X			X		X	X	X	43	28
18			X	X			X		X	X	X	43	28
19			X	X			X		X	X	X	43	28
20	X			X			X		X	X	X	43	28
21	X			X			X		X	X	X	43	28
22	X			X		X			X	X	X	43	28
23				X		X						43	28
24				X		X						43	28
25		X		X				X	X	X	X	43	29
26		X		X				X	X	X	X	43	29
27		X		X				X	X	X	X	43	29
28			X	X			X		X	X	X	43	29
29			X	X			X		X	X	X	43	29
30			X	X			X		X	X	X	43	29
31			X	X			X		X	X	X	43	29
32		X		X				X	X	X	X	43	29
33	X			X			X		X	X	X	43	29
34	X			X		X			X	X	X	43	29
35				X		X						43	29
36				X		X						43	29
37		X		X		-		X	X	X	X	44	29
38		X		X				X	X	X	X	44	29
39		X		X				X	X	X	X	44	29
40		X		X				X	X	X	X	44	29

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
41		X		X			X		X	X	X	44	29
42		X		X				X	X	X	X	44	29
43		X		X				X	X	X	X	44	29
44		X		X			X		X	X	X	44	29
45	X				X		X		X	X	X	44	29
46	X			X			X		X	X	X	44	29
47				X		X						44	29
48				X		X						44	29
49				X		X						44	29
50		X		X				X	X	X	X	44	29
51		X		X				X	X	X	X	44	29
52		X		X				X	X	X	X	44	29
53		X		X				X	X	X	X	44	29
54		X		X				X	X	X	X	44	29
55		X		X				X	X	X	X	44	29
56		X		X				X	X	X	X	44	29
57		X		X				X	X	X	X	44	29
58	X				X			X	X	X	X	44	29
59	X			X			X		X	X	X	44	29
60	X			X			X		X	X	X	44	29
61				X		X						44	29
62				X		X						44	29
63		X		X				X	X	X	X	45	29
64		X		X				X	X	X	X	45	29
65		X		X				X	X	X	X	45	29
66		X		X				X	X	X	X	45	29
67		X		X				X	X	X	X	45	29
68		X		X			X		X	X	X	45	29
69		X		X				X	X	X	X	45	29
70		X		X				X	X	X	X	45	29
71	X				X			X	X	X	X	45	29
72	X			X			X		X	X	X	45	29
73	X			X			X		X	X	X	45	29
74	X			X		X			X	X	X	45	29
75	X			X		X			X	X	X	45	29
76				X		X				X		45	29
77				X		X						45	29
78				X		X						45	29
79				X		X						46	29
80		X		X				X	X	X	X	46	29

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
81		X		X				X	X	X	X	46	29
82		X		X				X	X	X	X	46	29
83		X		X				X	X	X	X	46	29
84		X		X				X	X	X	X	46	29
85		X		X				X	X	X	X	46	29
86		X		X			X		X	X	X	46	29
87		X		X				X	X	X	X	46	29
88		X		X			X		X	X	X	46	29
89	X			X			X		X	X	X	46	29
90	X			X			X		X	X	X	46	29
91	X			X			X		X	X	X	46	29
92	X			X		X			X	X	X	46	29
93				X			X			X		46	29
94				X		X						46	29
95				X		X				X		46	29
96		X		X				X	X	X	X	46	29
97		X		X				X	X	X	X	46	29
98		X		X				X	X	X	X	46	29
99		X		X				X	X	X	X	46	29
100		X		X				X	X	X	X	46	29
101		X		X				X	X	X	X	46	29
102		X		X			X		X	X	X	46	29
103		X		X				X	X	X	X	46	29
104	X				X			X		X		46	29
105	X				X			X		X		46	29
106	X			X			X		X	X	X	46	29
107	X			X			X		X	X	X	46	29
108	X			X			X		X	X	X	46	29
109	X			X			X		X	X	X	46	29
110	X			X			X		X	X	X	46	29
111				X		X				X		46	29
112				X		X				X		46	29
113				X		X						46	29
114				X		X						46	29
115				X		X						46	29
116				X		X						46	29
117				X		X						47	29
118		X		X				X	X	X	X	47	29
119		X		X				X	X	X	X	47	29
120		X		X				X	X	X	X	47	29

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
121		X		X				X	X	X	X	47	29
122	X			X				X	X	X	X	47	29
123		X		X				X	X	X	X	47	29
124		X		X			X		X	X	X	47	29
125	X				X			X	X	X	X	47	29
126	X				X			X	X	X	X	47	29
127	X				X			X	X	X	X	47	29
128	X				X		X		X	X	X	47	29
129	X			X			X		X	X	X	47	29
130	X			X			X		X	X	X	47	29
131	X			X			X		X	X	X	47	29
132	X			X			X		X	X	X	47	29
133	X			X			X		X	X	X	47	29
134	X			X			X		X	X	X	47	29
135				X		X				X		47	29
136				X		X						47	29
137				X		X						47	29
138				X		X						47	29
139				X		X				X		48	29
140		X		X				X	X	X	X	48	29
141		X		X				X	X	X	X	48	29
142	X			X				X	X	X	X	48	29
143	X			X				X	X	X	X	48	29
144	X			X				X	X	X	X	48	29
145	X			X			X		X	X	X	48	29
146	X			X			X		X	X	X	48	29
147	X			X				X	X	X	X	48	29
148	X			X				X	X	X	X	48	29
149	X			X				X	X	X	X	48	29
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152	X			X			X		X	X	X	48	29
153	X			X			X		X	X	X	48	29
154	X			X				X	X	X	X	48	29
155	X			X			X		X	X	X	48	29
156	X			X			X		X	X	X	48	29
157	X			X		X			X	X	X	48	29
158				X		X				X		48	29
159				X		X						48	29
160				X		X						48	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
161				X			X					48	30
162		X		X				X	X	X	X	48	30
163	X			X				X	X	X	X	48	30
164	X			X				X	X	X	X	48	30
165	X			X			X		X	X	X	48	30
166	X			X			X		X	X	X	48	30
167	X			X				X	X	X	X	48	30
168	X			X				X	X	X	X	48	30
169	X			X				X	X	X	X	48	30
170	X			X			X		X	X	X	48	30
171	X			X			X		X	X	X	48	30
172	X			X			X		X	X	X	48	30
173	X			X			X		X	X	X	48	30
174	X			X			X		X	X	X	48	30
175	X			X			X		X	X	X	48	30
176	X			X			X		X	X	X	48	30
177	X			X			X		X	X	X	48	30
178	X			X			X		X	X	X	48	30
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186	X			X				X	X	X	X	49	30
187	X			X				X	X	X	X	49	30
188	X			X				X	X	X	X	49	30
189	X			X				X	X	X	X	49	30
190	X			X				X	X	X	X	49	30
191	X			X			X		X	X	X	49	30
192	X			X			X		X	X	X	49	30
193	X			X			X		X	X	X	49	30
194	X				X		X		X	X	X	49	30
195	X			X			X		X	X	X	49	30
196	X			X			X		X	X	X	49	30
197	X			X			X		X	X	X	49	30
198	X			X			X		X	X	X	49	30
199	X			X			X		X	X	X	49	30
200				X		X						49	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
201				X		X						49	30
202				X			X					49	30
203	X			X				X	X	X	X	49	30
204	X			X				X	X	X	X	49	30
205	X				X			X	X	X	X	49	30
206	X				X			X	X	X	X	49	30
207	X				X			X	X	X	X	49	30
208	X			X				X	X	X	X	49	30
209	X			X				X	X	X	X	49	30
210	X			X				X	X	X	X	49	30
211	X			X				X	X	X	X	49	30
212	X			X				X	X	X	X	49	30
213	X				X		X		X	X	X	49	30
214	X			X			X		X	X	X	49	30
215	X			X			X		X	X	X	49	30
216	X			X			X		X	X	X	49	30
217	X			X			X		X	X	X	49	30
218	X			X			X		X	X	X	49	30
219	X			X			X		X	X	X	49	30
220	X			X			X		X	X	X	49	30
221	X			X			X		X	X	X	49	30
222				X			X					50	30
223	X			X				X	X	X	X	50	30
224	X				X			X	X	X	X	50	30
225	X				X			X	X	X	X	50	30
226	X				X			X	X	X	X	50	30
227	X			X				X	X	X	X	50	30
228	X			X				X	X	X	X	50	30
229	X			X				X	X	X	X	50	30
230	X			X				X	X	X	X	50	30
231	X				X			X	X	X	X	50	30
232	X				X		X		X	X	X	50	30
233	X				X		X		X	X	X	50	30
234	X				X			X	X	X	X	50	30
235	X				X		X		X	X	X	50	30
236	X			X			X		X	X	X	50	30
237	X			X			X		X	X	X	50	30
238	X			X			X		X	X	X	50	30
239	X			X			X		X	X	X	50	30
240	X			X			X		X	X	X	50	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
241	X			X			X		X	X	X	50	30
242				X			X			X		51	30
243				X			X			X		51	30
244	X			X				X	X	X	X	51	30
245	X				X			X	X	X	X	51	30
246	X				X			X	X	X	X	51	30
247	X			X				X	X	X	X	51	30
248	X			X				X	X	X	X	51	30
249	X			X				X	X	X	X	51	30
250	X			X				X	X	X	X	51	30
251	X			X				X	X	X	X	51	30
252	X				X			X	X	X	X	51	30
253	X				X		X		X	X	X	51	30
254	X				X			X	X	X	X	51	30
255	X				X			X	X	X	X	51	30
256	X			X			X		X	X	X	51	30
257	X			X			X		X	X	X	51	30
258	X			X			X		X	X	X	51	30
259	X			X			X		X	X	X	51	30
260	X			X			X		X	X	X	51	30
261	X			X			X		X	X	X	51	30
262	X				X		X		X	X	X	51	30
263	X			X			X		X	X	X	51	30
264	X			X			X		X	X	X	51	30
265	X			X				X	X	X	X	51	30
266	X			X				X	X	X	X	51	30
267	X			X				X	X	X	X	51	30
268	X			X				X	X	X	X	51	30
269	X			X				X	X	X	X	51	30
270	X				X			X	X	X	X	51	30
271	X				X			X	X	X	X	51	30
272	X			X			X		X	X	X	51	30
273	X			X			X		X	X	X	51	30
274	X			X			X		X	X	X	51	30
275	X			X			X		X	X	X	51	30
276	X			X			X		X	X	X	51	30
277	X			X			X		X	X	X	51	30
278	X			X			X		X	X	X	51	30
279	X				X		X		X	X	X	51	30
280	X			X			X		X	X	X	51	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
281	X			X			X		X	X	X	51	30
282				X			X					52	30
283				X			X					52	30
284	X			X				X	X	X	X	52	30
285	X			X				X	X	X	X	52	30
286	X			X				X	X	X	X	52	30
287	X			X				X	X	X	X	52	30
288	X			X				X	X	X	X	52	30
289	X				X			X	X	X	X	52	30
290	X				X			X	X	X	X	52	30
291	X				X			X	X	X	X	52	30
292	X			X			X		X	X	X	52	30
293	X			X			X		X	X	X	52	30
294	X			X			X		X	X	X	52	30
295	X			X			X		X	X	X	52	30
296	X			X			X		X	X	X	52	30
297	X			X			X		X	X	X	52	30
298	X				X		X		X	X	X	52	30
299	X			X			X		X	X	X	52	30
300	X			X			X		X	X	X	52	30
301				X			X					53	30
302				X			X					53	30
303	X			X				X	X	X	X	53	30
304	X			X				X	X	X	X	53	30
305	X			X				X	X	X	X	53	30
306	X				X			X	X	X	X	53	30
307	X				X			X	X	X	X	53	30
308	X				X			X	X	X	X	53	30
309	X				X			X	X	X	X	53	30
310					X			X				53	30
311	X			X			X		X	X	X	53	30
312	X			X			X		X	X	X	53	30
313	X			X			X		X	X	X	53	30
314	X			X			X		X	X	X	53	30
315	X			X			X		X	X	X	53	30
316	X			X			X		X	X	X	53	30
317				X			X					53	30
318				X			X					53	30
319				X			X					53	30
320				X			X					53	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
321	X			X				X	X	X	X	53	30
322	X			X				X	X	X	X	53	30
323	X				X			X	X	X	X	53	30
324	X				X			X	X	X	X	53	30
325	X				X			X	X	X	X	53	30
326	X				X			X	X	X	X	53	30
327	X				X			X	X	X	X	53	30
328	X			X				X	X	X	X	53	30
329	X			X				X	X	X	X	53	30
330	X			X			X		X	X	X	53	30
331	X			X			X		X	X	X	53	30
332	X			X			X		X	X	X	53	30
333	X			X			X		X	X	X	53	30
334	X			X			X		X	X	X	53	30
335	X			X			X		X	X	X	53	30
336	X			X			X		X	X	X	53	30
337				X			X					54	30
338				X			X					54	30
339	X				X			X	X	X	X	54	30
340	X				X			X	X	X	X	54	30
341	X				X			X	X	X	X	54	30
342	X				X			X	X	X	X	54	30
343	X				X			X	X	X	X	54	30
344	X				X			X	X	X	X	54	30
345					X			X				54	30
346					X			X		X		54	30
347	X				X			X	X	X	X	54	30
348	X			X			X		X	X	X	54	30
349	X			X			X		X	X	X	54	30
350	X			X			X		X	X	X	54	30
351	X			X			X		X	X	X	54	30
352	X			X			X		X	X	X	54	30
353				X			X					54	30
354	X			X			X		X	X	X	54	30
355				X			X					54	30
356				X			X					54	30
357				X			X					54	30
358	X				X			X	X	X	X	54	30
359	X				X			X	X	X	X	54	30
360	X				X			X	X	X	X	54	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
361	X				X			X	X	X	X	54	30
362	X				X			X	X	X	X	54	30
363	X				X			X	X	X	X	54	30
364	X				X			X	X	X	X	54	30
365	X				X			X		X		54	30
366		X			X			X	X	X	X	54	30
367	X				X			X	X	X	X	54	30
368	X			X			X		X	X	X	54	30
369	X			X			X		X	X	X	54	30
370	X			X			X		X	X	X	54	30
371	X			X			X		X	X	X	54	30
372	X			X			X		X	X	X	54	30
373				X			X					54	30
374				X			X					54	30
375				X			X					54	30
376				X			X					55	30
377	X				X			X	X	X	X	55	30
378	X				X			X	X	X	X	55	30
379	X				X			X	X	X	X	55	30
380	X				X			X	X	X	X	55	30
381	X				X			X	X	X	X	55	30
382	X				X			X	X	X	X	55	30
383	X				X			X	X	X	X	55	30
384	X				X		X		X	X	X	55	30
385	X			X			X		X	X	X	55	30
386	X			X			X		X	X	X	55	30
387	X			X			X		X	X	X	55	30
388	X			X			X		X	X	X	55	30
389	X			X			X		X	X	X	55	30
390				X			X					55	30
391				X			X					55	30
392				X			X					56	30
393				X			X					56	30
394	X				X			X	X	X	X	56	30
395	X				X			X	X	X	X	56	30
396	X				X			X	X	X	X	56	30
397	X				X			X	X	X	X	56	30
398	X				X			X	X	X	X	56	30
399	X				X			X	X	X	X	56	30
400	X				X			X	X	X	X	56	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
401	X				X		X		X	X	X	56	30
402	X				X			X	X	X	X	56	30
403	X			X			X		X	X	X	56	30
404	X			X			X		X	X	X	56	30
405	X			X			X		X	X	X	56	30
406	X			X			X		X	X	X	56	30
407				X			X					56	30
408				X			X			X		56	30
409	X			X			X		X	X	X	56	30
410				X			X					56	30
411	X				X			X	X	X	X	56	30
412	X				X			X	X	X	X	56	30
413	X				X			X	X	X	X	56	30
414	X				X			X	X	X	X	56	30
415	X				X			X	X	X	X	56	30
416	X				X			X	X	X	X	56	30
417	X				X			X	X	X	X	56	30
418	X				X			X	X	X	X	56	30
419	X			X			X		X	X	X	56	30
420	X			X			X		X	X	X	56	30
421	X			X			X		X	X	X	56	30
422	X			X			X		X	X	X	56	30
423	X			X			X		X	X	X	56	30
424	X			X			X		X	X	X	56	30
425	X				X		X		X	X	X	57	30
426	X				X			X	X	X	X	57	30
427	X				X			X	X	X	X	57	30
428	X				X			X	X	X	X	57	30
429					X			X		X		57	30
430					X			X				57	30
431					X			X		X		57	30
432	X			X			X		X	X	X	57	30
433	X			X			X		X	X	X	57	30
434	X			X			X		X	X	X	57	30
435	X			X			X		X	X	X	57	30
436	X			X			X		X	X	X	57	30
437	X			X			X		X	X	X	57	30
438	X			X			X		X	X	X	57	30
439	X			X			X		X	X	X	57	30
440	X			X			X		X	X	X	57	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
441				X			X					58	30
442	X				X			X	X	X	X	58	30
443	X				X			X	X	X	X	58	30
444					X			X				58	30
445					X			X				58	30
446	X			X			X		X	X	X	58	30
447	X			X			X		X	X	X	58	30
448	X			X			X		X	X	X	58	30
449	X			X			X		X	X	X	58	30
450	X			X			X		X	X	X	58	30
451	X			X			X		X	X	X	58	30
452	X			X			X		X	X	X	58	30
453	X			X			X		X	X	X	58	30
454				X			X					58	30
455				X			X					58	30
456					X			X				58	30
457					X			X				58	30
458					X			X				58	30
459					X			X				58	30
460	X				X			X	X	X	X	58	30
461	X			X			X		X	X	X	58	30
462	X			X			X		X	X	X	58	30
463	X			X			X		X	X	X	58	30
464	X			X			X		X	X	X	58	30
465	X			X			X		X	X	X	58	30
466	X				X		X		X	X	X	58	30
467	X			X			X		X	X	X	58	30
468	X			X			X		X	X	X	58	30
469				X			X					59	30
470					X			X		X		59	30
471					X			X		X		59	30
472					X			X		X		59	30
473	X				X			X	X	X	X	59	30
474	X			X			X		X	X	X	59	30
475	X			X			X		X	X	X	59	30
476	X			X			X		X	X	X	59	30
477	X			X			X		X	X	X	59	30
478	X				X		X		X	X	X	59	30
479	X			X			X		X	X	X	59	30
480	X			X			X		X	X	X	59	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
481				X			X			X		59	30
482				X			X					60	30
483	X				X			X	X	X	X	60	30
484	X				X			X	X	X	X	60	30
485					X			X		X		60	30
486	X				X			X	X	X	X	60	30
487	X			X			X		X	X	X	60	30
488	X			X			X		X	X	X	60	30
489	X			X			X		X	X	X	60	30
490	X			X			X		X	X	X	60	30
491	X			X			X		X	X	X	60	30
492				X			X					60	30
493	X			X			X		X	X	X	60	30
494	X				X		X		X	X	X	60	30
495				X			X			X		60	30
496	X				X			X	X	X	X	60	30
497	X				X			X	X	X	X	60	30
498	X				X			X	X	X	X	60	30
499	X				X			X	X	X	X	60	30
500	X			X				X	X	X	X	60	30
501	X			X			X		X	X	X	60	30
502	X			X			X		X	X	X	60	30
503	X			X			X		X	X	X	60	30
504	X			X			X		X	X	X	60	30
505	X			X			X		X	X	X	60	30
506	X				X		X		X	X	X	60	30
507	X			X			X		X	X	X	60	30
508	X			X			X		X	X	X	60	30
509	X			X			X		X	X	X	61	30
510	X				X			X	X	X	X	61	30
511	X				X			X	X	X	X	61	30
512	X				X			X	X	X	X	61	30
513	X				X			X	X	X	X	61	30
514	X				X			X	X	X	X	61	30
515	X			X			X		X	X	X	61	30
516	X			X			X		X	X	X	61	30
517	X			X			X		X	X	X	61	30
518	X			X			X		X	X	X	61	30
519	X			X			X		X	X	X	61	30
520	X			X			X		X	X	X	61	30

Section number	Single stage evaporative cool[cut off]	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
521	X			X			X		X	X	X	61	30
522	X			X			X		X	X	X	61	30
523	X			X			X					61	30
524	X				X			X	X	X	X	61	30
525	X				X			X	X	X	X	61	30
526	X				X			X	X	X	X	61	30
527	X				X			X	X	X	X	61	30
528	X				X			X	X	X	X	61	30
529					X			X		X		61	30
530	X			X				X	X	X	X	61	30
531	X			X			X		X	X	X	61	30
532	X			X			X		X	X	X	61	30
533	X				X		X		X	X	X	61	30
534	X			X			X		X	X	X	61	30
535	X			X			X		X	X	X	61	30
536				X			X					61	30
537				X			X					62	30
538	X				X			X	X	X	X	62	30
539	X				X			X	X	X	X	62	30
540	X				X			X	X	X	X	62	30
541	X				X			X	X	X	X	62	30
542					X			X	X	X	X	62	30
543					X			X				62	30
544	X			X			X		X	X	X	62	30
545	X			X			X		X	X	X	62	30
546	X			X			X		X	X	X	62	30
547	X				X			X	X	X	X	62	30
548	X				X		X		X	X	X	62	30
549				X			X		X	X	X	62	30
550				X			X					62	30
551				X			X					63	30
552	X				X			X	X	X	X	63	30
553	X				X			X	X	X	X	63	30
554	X				X			X	X	X	X	63	30
555	X				X			X	X	X	X	63	30
556	X				X			X	X	X	X	63	30
557	X				X			X	X	X	X	63	30
558	X			X				X	X	X	X	63	30
559	X			X			X		X	X	X	63	30
560	X			X			X		X	X	X	63	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
561	X				X			X	X	X	X	63	30
562	X			X			X		X	X	X	63	30
563				X			X					63	30
564				X			X					63	30
565				X			X					63	30
566	X				X			X	X	X	X	63	30
567	X				X			X	X	X	X	63	30
568	X				X			X	X	X	X	63	30
569	X				X			X	X	X	X	63	30
570	X				X			X	X	X	X	63	30
571	X				X			X	X	X	X	63	30
572	X				X			X	X	X	X	63	30
573	X				X			X	X	X	X	63	30
574	X				X			X	X	X	X	63	30
575	X				X			X	X	X	X	63	30
576	X				X			X	X	X	X	63	30
577	X			X			X		X	X	X	63	30
578				X			X					63	30
579				X			X					64	30
580	X				X			X	X	X	X	64	30
581	X				X			X	X	X	X	64	30
582	X				X			X	X	X	X	64	30
583	X				X			X	X	X	X	64	30
584	X				X			X	X	X	X	64	30
585	X				X			X	X	X	X	64	30
586	X				X			X	X	X	X	64	30
587	X				X			X	X	X	X	64	30
588	X				X			X	X	X	X	64	30
589	X				X			X	X	X	X	64	30
590	X				X			X	X	X	X	64	30
591	X			X			X		X	X	X	64	30
592				X			X					64	30
593				X			X					65	30
594	X				X			X	X	X	X	65	30
595	X				X			X	X	X	X	65	30
596	X				X			X	X	X	X	65	30
597	X				X			X	X	X	X	65	30
598	X				X			X	X	X	X	65	30
599	X				X			X	X	X	X	65	30
600	X				X			X	X	X	X	65	30

Section number	Single stage evaporative cool	Dual stage evaporative cooler	Air conditioner	Air to air heat pump	Geothermal heat pump	R-19 insulation	R-30 insulation	R38 insulation	Whole house fan	Ceiling fans	Shade trees	Length of overhang (inches)	Depth of overhang (inches)
601	X				X			X	X	X	X	65	30
602	X				X			X	X	X	X	65	30
603	X				X			X	X	X	X	65	30
604	X				X		X		X	X	X	65	30
605				X			X					65	30
606				X			X					65	30
607				X			X					65	30
608	X				X			X	X	X	X	65	30
609	X				X			X	X	X	X	65	30
610	X				X			X	X	X	X	65	30
611	X				X			X	X	X	X	65	30
612	X				X			X	X	X	X	65	30
613	X				X			X	X	X	X	65	30
614	X				X			X	X	X	X	65	30
615	X				X			X	X	X	X	65	30
616	X				X			X	X	X	X	65	30
617	X				X			X	X	X	X	65	30
618	X				X			X	X	X	X	65	30
619				X			X			X		65	30
620				X			X					65	30
621				X			X					66	30
622	X				X			X	X	X	X	66	30
623	X				X			X	X	X	X	66	30
624	X				X			X	X	X	X	66	30
625	X				X			X	X	X	X	66	30
626	X				X			X	X	X	X	66	30
627	X				X			X	X	X	X	66	30
628	X				X			X	X	X	X	66	30
629	X				X			X	X	X	X	66	30
630	X				X			X	X	X	X	66	30
631	X				X			X	X	X	X	66	30
632	X				X			X	X	X	X	66	30
633				X			X			X		66	30
634				X			X					66	30
635				X			X					66	30